CRITERIA AIR CONTAMINANTS
EMISSIONS INVENTORY 2006 GUIDEBOOK

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PREFACE

The purpose of this guidebook is to provide information to government agencies, industry and industrial associations, non-governmental organizations and the public about the methods used for the compilation of area source emissions for the 2006 National Emissions Inventory of Criteria Air Contaminants. The 2006 emissions inventory was compiled by the provincial and territorial representatives of the Emissions and Projections Working Group of the Canadian Council of Ministers of the Environment and published in the summer of 2008. Relevant area source emission sectors are identified with sources of base quantity, emission factors and other information used to derive emissions of TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs and CO (and NH_3, where data were available) for the following major source categories:

- industrial sector;
- non-industrial fuel combustion sector;
- transportation sector;
- incineration sector;
- miscellaneous source sector; and
- open source sector.

The guidebook is arranged using these categories, with sections corresponding to specific contributing sectors within the above categories.

Contributions to this guidebook were prepared by scientists and engineers from the Criteria Air Contaminants Section of the Pollution Data Division within Environment Canada.

Note to Reader:

The information contained in the guidebook may have been updated owing to more recent information that may have become available after the publication of this document.

Please see the 'Addendum' for a description of any changes that were brought about to the guide since its publication.

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CHAPTER 1
GENERAL GUIDEBOOK INFORMATION

1.1 INTRODUCTION

For several years, the Emissions and Projections Working Group has compiled, maintained and updated emission inventories of criteria air contaminants. This information base on emission sources assists in defining environmental strategies and priorities, provides documentation to evaluate the effectiveness of emission control measures and provides data for source/receptor model development, exposure assessments and other research activities.

The overall objective in preparing this guidebook is to summarize, consolidate and describe the year 2006 area source inventory methods used on a sector-by-sector basis for compilation of the 2006 Canadian criteria air contaminant emissions inventory. The inventory was released in the summer of 2006. This guidebook is intended for users such as government agencies, industry and industrial associations, non-governmental organizations and the public. Accordingly, a reasonable level of detail is given in the guidebook in order that the resulting emissions can be readily interpreted by the user. It is recognized that inventories can be prepared in varying levels of detail and that the quality of the estimated emissions is regulated by the amount and quality of available information, time and resources. Improvements in inventory techniques and activity levels are ongoing.

It was beyond the scope of this study to document techniques used for the derivation of point source emissions. In some cases, the area source inventory methods described are used to complete emissions estimation for sectors known to be only partially inventoried by point source techniques. In such cases, reconciliation techniques are used to adjust the area source estimates accordingly.

Methods used for point source inventories are based on a "bottom-up" approach, using site-specific and source-specific emissions estimation techniques, and have inherently differing sources of uncertainty from those methods used for area source estimation. The area source inventory methods described in this guidebook were used to prepare inventories on a large geographical (provincial/territorial and federal) basis. The guidebook is not intended to be a guide for preparing point source inventories or environmental audits.

1.2 GUIDEBOOK ORGANIZATION

Each section of chapters 2 through 7 of this guidebook starts on a new page and deals with an individual sector. In this way, sections can be freely added or replaced with updated information. The sections are numbered using a chapter number, designating an emission category, followed by two numbers: for example, 2.1.2. The following conventions are followed in assigning the identifiers:

- *First number*: A sequential number designating an emission category, as follows:

Chapter number	Emission category
2	Industrial sector
3	Non-industrial fuel combustion sector
4	Transportation sector
5	Incineration sector
6	Miscellaneous source sector
7	Open source sector

- *Second number*: A sequential number assignment within the emission category; for example, in emission category 2 (industrial sector), sector 1 is asphalt mix production.

- *Third number*: A sequential number designating a section of the documentation for that sector; for example, in emission category 2 (industrial sector), sector 1 (asphalt mix production), section 2 is a sector description. The sections are as follows:

Section number	Contents
1	General description
2	Sector description
3	Inventory method
4	Activity level
5	Comparison of 2006 methods with previous methodology
6	Alternative methods used by provinces/territories
7	References
8	Guidebook sector documentation record

1.3 OVERVIEW OF EMISSIONS INVENTORY TECHNIQUES

1.3.1 Inventory Purpose

An emissions inventory is generally a comprehensive, accurate account of air pollutant emissions and associated data from sources within the inventory area over a specified time frame that can be used to determine the effect of emissions on ambient air quality. Environment Canada's Residual Discharge Information System II is a computerized database management system used to maintain data on major emission sources at the process resolution, using the point and area source approach. The data are compiled on a provincial/territorial and national basis, and the information can also be compiled on other geographical resolutions. In this respect, data may normally be used for:

- establishing emission trends, which may reflect economic activity, the influence of air pollution control legislation, and so on;
- dispersion and atmospheric chemistry modelling to define present and future air pollutant effects (e.g., acid deposition and oxidant formation);
- assessing present and future control strategy development; or
- energy analysis, research purposes and information dissemination.

Furthermore, data in this present form, or in conjunction with other information on file, can be used to quantify emissions within jurisdictions, to site ambient monitoring stations or to define emission attainment. However, these latter end uses are normally the responsibility of provincial/territorial regulatory agencies, which generally maintain more detailed source characteristics in permit files or emission inventories. The purpose of the current emission compilations has been directed mainly towards defining annual emission trends in Canada, in order to characterize the effects of control strategies that are being implemented in the various provinces/territories to reduce effects of air contaminants. Thus, consistency of methods in compiling emissions is an important consideration.

1.3.2 Point/Area Source Distinction and Reconciliation

It can normally be expected that the accuracy and utility of the emissions inventory will increase as a greater fraction of total emissions is included in the point source data file. That is, data in the point source file are more detailed and can be more reliable than data maintained in the area source file. However, greater resources and personnel are required to update point source data. In most instances, major sources of the criteria air pollutants have been accounted for in the Environment Canada point source inventory. In some cases, individual sources within the point source classification may not exceed a specified cut-off level (e.g., 100 t of SO_2 per year), but have been designated as point sources in order to maintain record consistency. Alternatively, some individual sources within the area or mobile source classification (e.g., large industrial boilers, engines or mineral processing kilns) may have emissions that exceed this amount but, for purposes of the Environment Canada inventory, remain within the current area source designation, since these emissions result almost entirely from the consumed fuels, which are accounted for in area stationary fuel combustion sectors. Similarly, some emission sources that exceed the cut-off level are, in certain instances, compiled as area sources, since they are too numerous to be maintained on an individual point source basis. Hence, point/area source distinctions or cut-off levels (and thus sources considered) can be expected to vary between federal and provincial/territorial inventories according to the intended application of the inventory data.

The following sources are considered area sources:

- small collective sources that are inventoried as a group, such as any small residential, governmental, institutional, commercial or industrial fuel combustion operations; on-site solid waste disposal facilities; and motor vehicles, aircraft, vessels or other transportation facilities; and
- other miscellaneous sources, which are too numerous to inventory as point sources.

Any of the following stationary sources of air pollutants that emit, or have the potential to emit, 100 t per year or more of any regulated pollutant are considered point sources:

- fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input;
- coal cleaning plants (with thermal dryers);
- kraft pulp mills;
- portland cement plants;
- primary zinc smelters;
- iron and steel mills;
- primary aluminum ore reduction plants;
- primary copper smelters;
- municipal incinerators capable of charging more than 250 t of refuse per day;
- hydrofluoric, sulfuric and nitric acid plants;
- petroleum refineries;
- lime plants;
- phosphate rock processing plants;
- coke oven batteries;
- sulfur recovery plants;
- carbon black plants (furnace process);
- primary lead smelters;
- fuel conversion plants;
- sintering plants;
- secondary metal production plants;
- chemical process plants;
- fossil fuel boilers (or any combination thereof) with total capacity of more than 250 million British thermal units per hour heat input;
- petroleum storage and transfer;
- ore processing plants;
- glass fibre processing plants; and
- charcoal production plants.

For many sectors, area source techniques have been used by Environment Canada to estimate the emissions on a provincial/territorial scale. However, as discussed in the previous section, many point sources from these sectors may be inventoried in the provincial/territorial point source inventories. In such cases, the emissions from these point sources must be removed from the Environment Canada area source inventory in order to avoid double counting. This process is called point and area source emission reconciliation. Reconciliation may also be done between the Environment Canada area source inventory estimates and area source estimates by provincial/territorial agencies. For the 2006 inventory, this occurred in situations where the provincial/territorial estimates were based on better and/or more detailed information or when the province/territory did not agree with the Environment Canada estimates.

1.3.3 General Approaches Used to Obtain Emission Data or Methods

Information from various reports and documents has been consolidated in the preparation of this guidebook. Methodologies used by Environment Canada in compiling the national emissions inventory are included, and, where appropriate, provincial/territorial/regional alternative area source methodologies are also documented. In general, activity level and other associated data were procured from provincial/territorial agencies or federal government departments. For some sectors, specialists were contracted to improve the knowledge base for inventory methods and/or activity level. In certain cases (e.g., Ontario and British Columbia), data were obtained by regional offices and forwarded for centralized processing. Data may be in the form of:

- actual emissions determined by the company (or association); or
- information necessary to permit officials of the regulatory agency to calculate the emissions.

Emissions were derived for a given process or operation by one or more of the following methods:

- *Mass balance approach*: A mass balance approach is one in which the atmospheric emission is determined from the difference between the amount of total solvent or sulfur, for example, contained in feed materials and that contained in the products or process wastes. Mass balances are most appropriately applied to fuel sulfur contributions and mineral processing activities where sufficient data are available to derive average sulfur contents of process streams. VOC emissions from solvent use are also generally readily estimated by mass balance.

- *Emission factors*: Emission factors are used where material balances are not technically feasible. Emission factors can be used to estimate the rate at which a pollutant is released to the atmosphere as a result of some process activity. Average values that are used for a given source category may differ from actual emissions for a specific facility and may be developed on the basis of source test or other data. A comprehensive list of emission factors (known as AP-42) has been developed by the U.S. EPA (1985, 1995) and is upgraded as information becomes available. Emission factors have also been developed by Environment Canada for specific source categories. The values indicated in this guidebook are factors obtained from U.S. EPA publications or Environment Canada reports or derived for specific sources.

- *Emission factor estimates*: Emission factor estimates may be determined from process knowledge or surmised using various assumptions related to the operation.

In all cases, the influence of control devices (e.g., pollutant removal efficiency) was considered where appropriate, and a separate contribution of process emissions from fuel use emissions was derived where feasible.

The procedures described in this guidebook follow a consistent approach of data collection. Provincial/territorial or regional regulatory agencies were primarily responsible for compiling point source emissions within their areal jurisdictions, and area source emissions were primarily compiled by federal government personnel. In some cases, provincial/territorial or regional agencies chose to provide their own estimates for sectors that were normally inventoried as area sources by Environment Canada; in other cases, alternative methods were used to calculate the emissions; in still other cases, point/area source reconciliation was used.

1.3.4 Principal Information Sources: Emissions

GVRD and FVRD. 2003. 2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed. Detailed Listing of Results and Methodology. Greater Vancouver Regional District and Fraser Valley Regional District. November. (www.gvrd.bc.ca/publications/file.asp?ID=684)

U.S. EPA. 1985. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 4th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/oldeditions.html)

U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/index.html)

1.3.5 Principal Information Sources: Activity Levels

Natural Resources Canada. 2000. Coal and coke. In: Canadian Minerals Yearbook, 2000. (www.nrcan.gc.ca/mms/cmy/2000CMY_e.html)

Statistics Canada web site: www.statcan.ca

1.4 GLOSSARY

Term	Definition
Activity level	The process-level base quantity or rate relating to the amount of fuel consumed, quantity of product manufactured in an industrial process or some comparative measure within a given time period.
Air pollutant	Any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material and by-product material) substance or matter that is emitted into or otherwise enters the ambient air.

Area source	Small collective sources that are inventoried as a group, such as any small residential, governmental, institutional, commercial or industrial fuel combustion operations; on-site solid waste disposal facilities; and motor vehicles, aircraft, vessels or other transportation facilities; as well as other miscellaneous sources, which are too numerous to inventory as point sources.
Criteria air contaminant	For the purposes of this guidebook, the following pollutants are included: total particulate matter, PM_{10}, $PM_{2.5}$, sulfur oxides, nitrogen oxides, volatile organic compounds and carbon monoxide. Ammonia data are presented for sectors where such information is readily available and more fully documented in a separate guidebook.
Emission	The act of releasing or discharging air pollutants into the ambient air from any source. Also, the air pollutants discharged from any source.
Emission factor	An estimate of the rate at which a pollutant is released to the atmosphere as a result of some activity, such as combustion or industrial production, divided by the level of that activity.
Facility	An identifiable piece of process equipment. A stationary source is composed of one or more pollutant-emitting facilities.
Fossil fuel	Natural gas, petroleum, coal and any form of solid, liquid or gaseous fuel derived from such material for the purpose of creating useful heat.
Fuel-burning equipment	Any furnace, boiler, apparatus, stack or other unit used in the process of burning fuel for the primary purpose of producing heat or power by indirect heat transfer.
Fuel evaporative emissions	Vaporized fuel emitted into the atmosphere from the fuel system of a motor vehicle.
Fugitive emissions	Those emissions that do not pass through a stack, chimney, vent or other functionally equivalent opening.
Mobile source	Includes light-duty gasoline-powered vehicles; light-duty and heavy-duty diesel-powered vehicles; light-duty and heavy-duty gasoline-powered trucks; gaseous-fuelled vehicles; motorcycles; aircraft; locomotives; inboard and outboard powered vessels; agricultural equipment; heavy-duty construction equipment; snowmobiles; all-terrain vehicles; and small, general utility engines.
Nitrogen oxides	All oxides of nitrogen except nitrous oxide.
Particulate matter	Any finely divided solid or liquid material, other than uncombined water.
Point source	Any of the following stationary sources of air pollutants that emits, or has the potential to emit, 100 t per year or more of any regulated pollutant: fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input, coal cleaning plants (with thermal dryers), kraft pulp mills, portland cement plants,

	primary zinc smelters, iron and steel mill plants, primary aluminum ore reduction plants, primary copper smelters, municipal incinerators capable of charging more than 250 t of refuse per day, hydrofluoric, sulfuric and nitric acid plants, petroleum refineries, lime plants, phosphate rock processing plants, coke oven batteries, sulfur recovery plants, carbon black plants (furnace process), primary lead smelters, fuel conversion plants, sintering plants, secondary metal production plants, chemical process plants, fossil fuel boilers (or combination thereof) totalling more than 250 million British thermal units per hour heat input, petroleum storage and transfer ore processing plants, glass fibre processing plants and charcoal production plants.
Process	Any action, operation or treatment of materials, including handling and storage thereof, that may cause discharge of an air contaminant or contaminants into the atmosphere, but excluding fuel burning.
Process operation	Any chemical, industrial or manufacturing operation including, but not limited to, heat transfer, fluid flow, evaporation, humidification, absorption, extraction, distillation, drying, mixing, classification, sedimentation, decantation, filtration, crystallization, centrifugation, disintegration and material handling.
Process source	Any operation or process that produces an air contaminant resulting from the separation of the air contaminant from the process material or the conversion of constituents of the process material into air contaminants and that is not an air pollution abatement operation.
Stack	Any chimney flue, conduit or duct arranged to conduct emissions to the ambient air.
Stationary source	Any structure, building, facility or installation that emits or may emit any regulated pollutant to air.
Volatile organic compounds (VOCs)	Volatile compounds that participate in atmospheric photochemical reactions, excluding the following:

Substances not considered VOCs

Name of substance or group of substances	CAS No.
(a) methane	74-82-8
(b) ethane	74-84-0
(c) methylene chloride (dichloromethane)	75-09-2
(d) 1,1,1-trichloroethane (methyl chloroform)	71-55-6
(e) 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113)	76-13-1
(f) trichlorofluoromethane (CFC-11)	75-69-4
(g) dichlorodifluoromethane (CFC-12)	75-71-8
(h) chlorodifluoromethane (HCFC-22)	75-45-6
(i) trifluoromethane (HFC-23)	75-46-7
(j) 1,2-dichloro-1,1,2,2-tetrafluoroethane (CFC-114)	76-14-2
(k) chloropentafluoroethane (CFC-115)	76-15-3
(l) 1,1,1-trifluoro-2,2-dichloroethane (HCFC-123)	306-83-2
(m) 1,1,1,2-tetrafluoroethane (HFC-134a)	811-97-2
(n) 1,1-dichloro-1-fluoroethane (HCFC-141b)	1717-00-6

(o) 1-chloro-1,1-difluoroethane (HCFC-142b)	75-68-3
(p) 2-chloro-1,1,1,2-tetrafluoroethane (HCFC-124)	2837-89-0
(q) pentafluoroethane (HFC-125)	354-33-6
(r) 1,1,2,2-tetrafluoroethane (HFC-134)	359-35-3
(s) 1,1,1-trifluoroethane (HFC-143a)	420-46-2
(t) 1,1-difluoroethane (HFC-152a)	75-37-6
(u) parachlorobenzotrifluoride (PCBTF)	98-56-6
(v) cyclic, branched or linear completely methylated siloxanes	various
(w) acetone	67-64-1
(x) perchloroethylene (tetrachloroethylene)	127-18-4
(y) 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca)	422-56-0
(z) 1,3-dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	507-55-1
(z.1) 1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC-43-10mee)	138495-42-8
(z.2) difluoromethane (HFC-32)	75-10-5
(z.3) ethylfluoride (HFC-161)	353-36-6
(z.4) 1,1,1,3,3,3-hexafluoropropane (HFC-236fa)	690-39-1
(z.5) 1,1,2,2,3-pentafluoropropane (HFC-245ca)	679-86-7
(z.6) 1,1,2,3,3-pentafluoropropane (HFC-245ea)	24270-66-4
(z.7) 1,1,1,2,3-pentafluoropropane (HFC-245eb)	431-31-2
(z.8) 1,1,1,3,3-pentafluoropropane (HFC-245fa)	460-73-1
(z.9) 1,1,1,2,3,3-hexafluoropropane (HFC-236ea)	431-63-0
(z.10) 1,1,1,3,3-pentafluorobutane (HFC-365mfc)	406-58-6
(z.11) chlorofluoromethane (HCFC-31)	593-70-4
(z.12) 1-chloro-1-fluoroethane (HCFC-151a)	1615-75-4
(z.13) 1,2-dichloro-1,1,2-trifluoroethane (HCFC-123a)	354-23-4
(z.14) 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane $(C_4F_9OCH_3)$	163702-07-6
(z.15) (difluoromethoxymethyl)-1,1,1,2,3,3,3-heptafluoropropane $((CF_3)_2CFCF_2OCH_3)$	163702-08-7
(z.16) 1-ethoxy-1,1,2,2,3,3,4,4,4-nonafluorobutane $(C_4F_9OC_2H_5)$	163702-05-4
(z.17) (ethoxydifluoromethyl)-1,1,1,2,3,3,3-heptafluoropropane $((CF_3)_2CFCF_2OC_2H_5)$	163702-06-5
(z.18) methyl acetate	79-20-9
Perfluorocarbon compounds that fall into these classes:	
(i) cyclic, branched or linear completely fluorinated alkanes	various
(ii) cyclic, branched or linear completely fluorinated ethers with no unsaturations	various
(iii) cyclic, branched or linear completely fluorinated tertiary amines with no unsaturations	various
(iv) sulfur-containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine	various

1.5   LIST OF ACRONYMS

AB	Alberta
AP-42	U.S. EPA publication *Compilation of Air Pollutant Emission Factors*
BC	British Columbia
BEIS	Biosphere Emissions and Interactions System
CAC	criteria air contaminants: CO, VOCs, NO_x, SO_x, TPM, PM_{10}, $PM_{2.5}$, NH_3
CANBEIS	Canadian Biogenic Emissions Inventory System
CANSIM	Canadian Socioeconomic Information Management database
CAS	Chemical Abstracts Service

CH_4	methane
CLFV	Canadian portion of the Lower Fraser Valley study area
CO	carbon monoxide
CO_2	carbon dioxide
CSA	Canadian Standards Association
EF	emission factor
EPA	United States Environmental Protection Agency
FIRE	Factor Information Retrieval Data System
g	gram
GDP	gross domestic product
GJ	gigajoule
GloBEIS	Global Biosphere Emissions and Interactions System
GVWR	gross vehicle weight rating
h	hour
H_2S	hydrogen sulfide
ha	hectare
HDDV	heavy-duty diesel vehicle
HDGV	heavy-duty gasoline vehicle
J	joule
kg	kilogram
kl	kilolitre
km	kilometre
kt	kilotonne
LAI	leaf area index
lb.	pound
LDDT	light-duty diesel truck
LDDV	light-duty diesel vehicle
LDGT	light-duty gasoline truck
LDGV	light-duty gasoline vehicle
LMD	leaf mass density
LTO	landing and take off cycle
m	metre
m^2	square metre
m^3	cubic metre
MB	Manitoba
MC	motorcycle
mm	millimetre
Mt	megatonne
N_2	nitrogen gas
NB	New Brunswick
ng	nanogram
NH_3	ammonia
NL	Newfoundland and Labrador
NO_x	nitrogen oxides
NS	Nova Scotia
NT	Northwest Territories

NU	Nunavut
OECD	Organisation for Economic Co-operation and Development
ON	Ontario
PC-BEIS	personal computer version of the Biogenic Emissions Inventory System
PE	Prince Edward Island
$PM_{2.5}$	fine particulate matter, particles less than or equal to 2.5 microns in diameter
PM_{10}	inhalable particulate matter, particles less than or equal to 10 microns in diameter
ppm	parts per million
ppmv	parts per million by volume
QC	Quebec
SCC	Source Category Classification
SCG	Standard Classification of Goods
SHEU	Survey of Household Energy Use
SIC	Standard Industrial Classification
SK	Saskatchewan
SO_x	sulfur oxides
SO_2	sulfur dioxide
t	tonne
TEQ	toxicity equivalent
TPM	total particulate matter
VKT	vehicle kilometres travelled
VOC	volatile organic compound
wt	weight
YT	Yukon Territory

CHAPTER 2
INDUSTRIAL SECTOR

INDUSTRIAL SECTOR

2.1 ASPHALT MIX PRODUCTION

2.1.1 General Description

Asphalt concrete (or hot-mix asphalt) is manufactured by mixing asphalt cement with aggregates. There are approximately 600 plants located across Canada in rural and urban locations (Senes Consultants 2008). In 2006, no hot-mix asphalt production was reported for Nunavut. Ontario, Quebec and Alberta had the highest level of activity for this sector. More than 60 million tonnes of asphalt was estimated to have been produced in 2006.

2.1.2 Sector Description

Hot-mix asphalt paving, also called asphaltic concrete paving or asphalt concrete, is a heated mixture of graded aggregate and asphalt cement. The plants that produce hot-mix asphalt can be either permanent or portable installations. Particulate matter is the principal emission from these plants.

Cut-back paving operations, in which asphalt cement is liquefied with petroleum solvents, are also a potential source of VOCs. However, this operation is currently inventoried under general solvent use. Asphalt production and blowing are inventoried as part of petroleum refineries. Asphalt roofing manufacture is also inventoried separately.

Hot-mix asphalt can be manufactured by a batch mix or drum mix process. Conventional batch hot-mix asphalt plants operate with the following processes:

- heating and drying the aggregate fillers (i.e., sand, fragments of stone and gravel);
- screening and classifying the hot aggregate into bins;
- measuring and mixing the aggregate in the desired proportions into a pugmill;
- adding the asphalt cement to the aggregate mixture in the pugmill; and
- transferring the hot mixture to trucks and, subsequently, transporting the product to the paving site.

These asphalt plants can vary in the final mixing process, which may also be done in a continuous mode of operation. In more recent technology, drum mixing plants heat and mix the asphalt and the aggregates in the dryer "drum" in a single step. Emissions to the air from these operations have, to date, been inventoried as area sources (Asphalt Production – Fugitive and Mixing).

Asphalt mixing plants produce both fugitive and direct particulate emissions from dryer operations. Fugitive particulates originate in screens, open buckets, elevators, weigh hoppers, asphalt heaters, storage piles and bins (Formica 1976), as well as traffic re-

entrainment of yard dust. Most fugitive emissions associated with the process, however, can be eliminated when the sources are properly sealed (Robert et al. 1975).

The primary source of particulate emissions is the dryer, where aggregate constituents are dried before mixing. Because substantial percentages (70%) of particles are greater than 15 mm, primary control devices are generally used to remove these larger particles. The simplest and least costly dry collector is the expansion chamber, which may also be fitted with one or more baffles, called skimmers, and is known to have efficiencies of up to 50% for particulates above 40 mm (Robert et al. 1975). Cyclones are also used for primary collection of coarse particles, but finer fractions are removed with diminishing efficiencies in the order of 33% for particle sizes between 1 and 2.5 mm. For this reason, secondary control devices, such as centrifugal scrubbers and orifice scrubbers, are widely used, which provide collection efficiencies of approximately 90% for particles >5 mm and 99.5% for those >10 mm. High-energy venturi scrubbers are used less frequently, and fabric filters with efficiencies up to 99.9% for particles >0.05 mm are used to some extent (Robert et al. 1975).

2.1.3   Inventory Method

For 2006, asphalt mix production was inventoried as an area source of for the seven criteria air contaminants (TPM, PM_{10}, $PM_{2.5}$, SOx, NOx, VOC and CO), heavy metals (Pb, Cd, and Hg), dioxins and furans and PAH. There was no Ammonia emission from this sector. Subsequent reconciliation for point sources was done for all the provinces and territories except for Nunavut where there was no asphalt production reported.

Emission factors used in the inventory was based on the survey of the asphalt manufacturing plants done in 2008 (Senes Consultants 2008). Due to inconsistency in the survey returns form some of the asphalt manufacturing facilities in some provinces, average emission factors were used to estimate emissions (see spreadsheet for details). Emissions for all provinces/territories were estimated using emission factors and Canadian activity level data. Fugitive emissions arise from storage and handling.

2.1.4   Activity Level

Statistics Canada Catalogue No. 57-003-XWE lists asphalt consumed (all categories) in 2006 by province/territory (from Statistics Canada energy use database). Background literature suggests that 97% of these quantities were used for mixing purposes. Asphalt mix is 93% aggregate and 7% asphalt by mass

2.1.5   Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 2005 inventory for this sector.

2.1.6 Alternative Methods Used by Provinces/Territories

No alternative methods were used by any provinces or territories.

2.1.7 References

Formica, P.N. 1976. Controlled and Uncontrolled Emission Rates and Applicable Limitations for Eighty Processes. NTIS PB-266 378 (cited in SNC/GECO Canada Inc. and Ontario Research Foundation 1981).

Robert, J. , Hutchison, D. and DiBartolo, B. 1975. Air Pollution Emissions and Control Technology Asphalt Paving Industry. Report EPS 3-AP-74-2 (cited in SNC/GECO Canada Inc. and Ontario Research Foundation 1981).

SNC/GECO Canada Inc. and Ontario Research Foundation. 1981. A Nationwide Inventory of Anthropogenic Sources and Emissions of Primary Fine Particulate Matter. Prepared for Environment Canada.

Statistics Canada. Report on Energy Supply and Demand, Catalogue No. 57-003-XWE.

Senes Consultants 2008. Update of Process Emission Profiles for Hot Mix Asphalt (HMA) Manufacturing Establishments across Canada.

2.1.8 Guidebook Sector Documentation Record

Release Version: 2

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Author: Mahesh Kashyap, Pollution Data Division

INDUSTRIAL SECTOR

2.2   BAKERIES

2.2.1   General Description

The bread and bakery industry in Canada consists of three types of establishment. The first produces bakery mixes and frozen dough/preformed products for wholesale distribution. The second is involved in dough mixing, kneading and baking to manufacture bakery products such as bread, rolls and pastries, also for wholesale distribution. The third group is retail bakeries, which bake and sell their products directly to the consumer on the premises (Agriculture and Agri-Food Canada 2000).

Shipped bakery products (including exports) valued at $5.4 billion in 2006 (Statistics Canada, 304-0015). Most of the major corporations that produce fresh bakery goods in Canada operate through branch operations that vary in size according to the density of population in the area (Agriculture and Agri-Food Canada 2000). Ontario, British Columbia and Quebec accounted for majority of the bread production for 2006.

2.2.2   Sector Description

In the baking industry, VOCs are released by the leavening process. Emissions from products leavened by baking powder (used mainly for pastries) are negligible. However, hydrocarbons are released when yeast is used for leavening. Yeast is used nearly exclusively in the production of bread and bread-like pastries.

Straight dough and sponge dough are the two main processes used in the commercial production of bread. In the straight dough process, fermentation occurs after all ingredients are mixed. Sponge dough is fermented with just part of the ingredients; the remaining ingredients are added and ferment just prior to baking. The fermentation process takes from 2 to 4 hours. Oven temperatures are generally around 230°C. Any vapours from the bread baking or due to combustion (usually natural gas) are generally removed through the same vent.

Although CO_2 is produced during fermentation, it remains in the bread. Ethanol is released to the atmosphere during both the fermentation and baking stages. No controls or process modifications are used to reduce ethanol emissions from bakeries. Bakery emissions arising from the consumption of natural gas are inventoried as part of the industrial fuel consumption area source sector.

2.2.3   Inventory Method

For 2006, Bakeries were inventoried as area sources of VOCs using emission factors based on the surveys conducted by Environment Canada in 2004 with subsequent

reconciliation for point sources for the provinces of British Columbia, Alberta, Saskatchewan, Quebec, Manitoba, Newfoundland, Nova Scotia, New Brunswick, and Ontario. There were no point sources reported for other provinces and territories.

VOC emission factor of 2.35 kg per tonne of baked goods was used for all provinces/territories except for Ontario and British Columbia where the emission factors used were 2.4 kg/tonne (Environment Canada 2005) and 2.41 kg/tonne (Environment Canada. 2007)respectively. These values were based on the survey...

2.2.4   Activity Level

Statistics Canada no longer provides the quantities of bread produced by province, as this information is now protected by confidentiality agreements with individual bread-making establishments.

In the absence of real production figures, the amount of bread produced was estimated using the value of shipments of goods of own manufacture ($5.4 billion) along with the year 2006 production (tonnes) and 2006 value of shipments of goods of own manufacture. The price indexes from Statistics Canada Catalogue No. 62-011-XWE were used (bread and rolls)

2.2.5   Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 2005 inventory for this sector.

2.2.6   Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces.

2.2.7   References

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Environment Canada. 2007. Survey of Commercial Baking Establishments in British Columbia

Agriculture and Agri-Food Canada. 2000. The Canadian Bread and Bakery Industry. Sub-Sector Profile. Food Bureau, Agriculture and Agri-Food Canada. July. (www.agr.gc.ca)

Statistics Canada, 304-0015 Manufacturing sales, by North American Industry Classification System (NAICS) and province, monthly (dollars) Jan 1992 to Sep 2008. Data provided by Agriculture and Agri-Food Canada.

Statistics Canada. Industrial product price indexes, by commodity and commodity aggregations — Fruit, vegetable, feeds and other food products. Catalogue No. 62-011-XWE, Table 2-3.

2.2.8   Guidebook Sector Documentation Record

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Author: Mahesh Kashyap, Pollution Data Division

INDUSTRIAL SECTOR

2.4   COAL MINING AND PROCESSING 2006

2.4.1   General Description

In Canada, 90% of coal produced is used mainly as fuel for the generation of electricity (Natural Resources Canada 2002). The remaining 10% is used for industrial process heating or residential heating and transformed into other materials, such as activated carbon for water treatment plants.

In Canada, during 2005, coal was mined in five provinces: British Columbia, Alberta, Saskatchewan, New Brunswick and Nova Scotia (Natural Resources Canada, 2005). Coal is imported by ship and transported across Canada by train or truck. Most coal is transported typically over distances of 1100 km (Cope and Bhattacharyya 2001).

2.4.2   Sector Description

Coal undergoes the following processes prior to consumer distribution: mining, loading/unloading, cleaning and transporting, and importing to terminals. These processes include many steps that generate mostly particulate emissions, except in the case of coal cleaning, which involves a drying step producing SO_x, NO_x, CO and VOC emissions. Estimation methods for emissions from coal combustion, which is not included in the processing of coal, are found in the industrial fuel combustion (section 2.15) and off-road vehicles and engines (section 4.2) sectors of this guidebook.

Coal Mining

The majority of coal in Canada is mined in surface operations referred to as open area, open pit or strip mines (Cope and Bhattacharyya 2001). In surface or open pit mining, all operations that involve exposure of overburden, coal or equipment generate some amount of fugitive dust (particulate matter emissions). Principal mining operations include topsoil and subsoil removal to reclamation sites, blasting/removal of overburden to spoil piles, drilling/blasting and removal of the coal to storage piles or cleaning/crushing operations. Wind erosion affects disturbed areas until they are revegetated.

Coal Cleaning

Coal cleaning is a process by which impurities such as sulfur, ash and rock (or overburden) are removed from coal to upgrade its value. Coal cleaning processes are categorized as either physical cleaning or chemical cleaning. The most common cleaning processes in use today are the physical coal cleaning processes that involve the mechanical separation of contaminants from the coal using variations in density. Chemical coal cleaning processes are generally not commercially practical. Emissions of

particulate matter, NO_x, SO_x and VOCs are inventoried for coal cleaning as by-products of the combustion process used for drying.

The steps used in physical coal cleaning processes vary among coal cleaning plants but can generally be divided into four basic phases: initial preparation, fine coal processing, coarse coal processing and final preparation.

In the initial preparation phase, the raw coal is unloaded, stored, conveyed, crushed, screened, classified and stored in coarse and fine coal fractions. The size fractions are then conveyed to their respective cleaning processes. These processes are inventoried under materials handling.

Fine coal and coarse coal processing use very similar operations and equipment to separate contaminants. The primary differences are the severity of operating parameters. The majority of coal-cleaning processes use upward currents or pulses of a fluid such as water to fluidize a bed of crushed coal and impurities. The lighter coal particles rise and are removed from the top of the bed. The heavier impurities are removed from the bottom. Coal cleaned in the wet processes must then be dried in the final preparation processes.

The final preparation processes remove moisture from coal. This reduces freezing problems and weight and improves the heating value of the coal. The first processing step is dewatering, in which a major portion of the water is removed by the use of screens, thickeners and cyclones. The second step is normally thermal drying, achieved by any one of three dryer types: fluidized bed, flash and multilouvred dryers. In the fluidized bed dryer, the coal is suspended and dried above a perforated plate by rising hot gases. In the flash dryer, coal is fed into a stream of hot gases for instantaneous drying. The dried coal and wet gases are drawn up a drying column and into a cyclone for separation. In the multilouvred dryer, hot gases are passed through a falling curtain of coal. The coal is lifted by flights of a specially designed conveyor. Alternatively, when the coal separation processes have not involved wet separation processes, drying may employ less complicated systems, such as rotary dryers.

The major source of emissions from the final preparation phase is the thermal dryer exhaust. This exhaust stream contains coal particles entrained in the drying gases, in addition to the standard products of coal combustion resulting from burning coal to generate hot gases. The most common technologies used to control the particulate from the final preparation are venturi scrubbers and mist eliminators downstream from the product recovery cyclones. The particulate control efficiency of these technologies ranges from 98% to 99.9%. The venturi scrubbers have an NO_x removal efficiency of 10–25% and an SO_x removal efficiency ranging from 70–80% for low-sulfur coals to 40–50% for high-sulfur coals (ORTECH 1999).

Transport

Coal transportation emissions include only those particulate matter emissions resulting from the coal itself during coal transit. Load-in and load-out losses have been included in the mining and handling sector and at the plant as part of fugitive emissions. Emissions from fuel combustion (diesel, gasoline or oil) are inventoried separately as part of the transportation sector. Before transport, the coal is often sprayed with chemical binders to reduce fugitive dust emissions (SNC/GECO Canada Inc. and Ontario Research Foundation 1981).

Most of the coal mined in Canada is carried to trans-shipment or export terminals by unit trains. The coal imported into Canada is shipped in lake vessels. Some minor amounts of coal are shipped by truck (Cope and Bhattacharyya 2001).

2.4.3   Inventory Method

Emission factors are used in the calculation of emissions for the following sources: coal mining, coal cleaning, coal transportation and coal terminals or end-use facilities. Coal mining includes raw coal loading, raw coal unloading, overburden removal.

Coal Mining and Cleaning

For mining and cleaning operations, TPM emission factors based on weight (tonnes) of material handled were taken from section 11.9 of AP-42, 5th edition (U.S. EPA 1995) and from factors used in previous Environment Canada inventories. PM_{10} and $PM_{2.5}$ emission factors were derived from the total particulate emission factors for mining and cleaning operations using data from the U.S. EPA SPECIATE software:

$$EF_{PM10} = 0.545 EF_{TPM}$$
$$EF_{PM2.5} = 0.33 EF_{TPM}$$

Tables 2.4-1 and 2.4-2 give the emission factors for coal mining and cleaning, respectively.

Table 2.4-1: Coal Mining Emission Factors

Sources	Emission factors (kg/t)		
	TPM	PM_{10}	$PM_{2.5}$
Mining	0.0130	0.0071	0.0043
Raw coal loading	0.0200	0.0109	0.0066
Raw coal unloading	0.0330	0.0180	0.0109
Overburden removal	0.0060	0.0033	0.0020

Table 2.4-2: Coal Cleaning Emission Factors

Source	Emission factors (kg/t)					
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs
Coal cleaning	0.0500	0.0273	0.0165	0.1300	0.0700	0.0500

Coal Transportation

For coal transportation, average emission factors were derived from the quantities of coal transported by rail, the distance traveled on the railroad and the type of containment of the coal (control, closed environment, covered wagon, etc.). For each distance traveled an emission factor is calculated (Ortech, 1991):

$$EF_{TPM,total} = 0.1*(0.62*D)^{0.6}$$

Where:

EF = the emission factor (kg/t of coal transported) [kg/tonne]

D = the distance travelled by rail cars or truck in a province [km]

This formula confirms the findings of several researchers: for coal carried at least 1100 km over rough terrain, 0.5% of the load is being emitted in the absence of controls. The formula provided above yields the uncontrolled EF.

Assuming that the formula is linear with respect to percent control of particulate matter and that the percent control in Canada is actually 99 % for rail transport of coal, the formula was adjusted to become (Cope et al, 2001):

$$EF_{TPM,total} = 0.1*(0.62*D)^{0.6} \frac{(100-99)}{100}$$

Emission factors for a distance segment in a province is calculated using a proportion of distance segment to total distance travelled:

$$EF(prorated) = EF * \frac{d}{D}$$

Where:

d = distance segment travelled

The weather also has an influence on the particulate emissions; rainy days will impede particulate releases by water falling on the load of coal. Days with a given minimum of snow or rain, as recorded by Environment Canada's Canadian Climate Summary website (2005), are considered precipitation days. Days with trace precipitation will be

considered non-rainy days for this estimation method. The ratio of non-rainy days to total days is used as a correction factor for precipitation (Cope and Bhattacharyya 2001).

$$EF_{final} = EF * \frac{(365 - P)}{365}$$

Where:

P = number of precipitation days

Recommended PM$_{10}$ and PM$_{2.5}$ Distribution Factors for Coal Transportation

The recommended distribution factors to convert TPM emission estimates to PM$_{10}$ and PM$_{2.5}$ emission estimates are those assigned by the U.S. EPA for wind erosion of storage piles and are being applied to rail coal cars. These scaling factors were found to better reflect rail car emissions than a stationary stockpile that is not subject to vibration:

$$EF_{PM10} = 0.5 EF_{TPM}$$
$$EF_{PM2.5} = 0.2 EF_{TPM}$$

Coal Terminals and End-Use Facilities

Emission factors for coal terminals are from previous CAC inventories. Table 2.4-3 summarized the emission factors used.

Table 2.4-3: Terminal and End-Use Facility Emission Factors for Coal

Sources	Emission factors (kg/t)		
	TPM	PM$_{10}$	PM$_{2.5}$
Coal Terminal and End-Use Facilities	0.1298	0.0649	0.0260

2.4.4 Activity Level

No activity levels were available in 2006, 2005 activity levels were therefore used. In 2005 the following method for estimating activity levels were used.

Coal

As stated in section 2.4.1, coal was mined in 5 provinces: British Colombia, Alberta, Saskatchewan, New Brunswick, and Nova Scotia. Statistical data provided total gross coal production for British Columbia, Alberta, Saskatchewan and total of Canada (Natural Resources Canada, 2005). Gross coal production data for Nova Scotia and New Brunswick was considered confidential. Therefore it was necessary to use 2004 data to distribute the production data to these two provinces.

To allocate the gross coal production for Nova Scotia and New Brunswick, allocations from 2004 were used with remainder of the 2005 Canada gross coal production when the other 3 provinces' productions are subtracted.

$$Gross \ Pr\,oduction_{NB,NS,2005} = Gross \ Pr\,oduction_{Canada2005} - Gross \ Pr\,oduction_{BC,SK,AB,2005}$$

$$Gross \ Pr\,oduction_{NS,2005} = Gross \ Pr\,oduction_{NS,NB,2005} * \frac{Gross \ Pr\,oduction_{NS,2004}}{Gross \ Pr\,oduction_{NS,2004} + Gross \ Pr\,oduction_{NB,2004}}$$

$$Gross \ Pr\,oduction_{NB,2005} = Gross \ Pr\,oduction_{NS,NB,2005} * \frac{Gross \ Pr\,oduction_{NB,2004}}{Gross \ Pr\,oduction_{NS,2004} + Gross \ Pr\,oduction_{NB,2004}}$$

Where:

$Gross \ Production_{NS,NB,2005}$ = 2005 gross coal production of New Brunswick and Nova Scotia combined

$Gross \ Production_{BC,SK,AB,2005}$ = 2005 gross coal production of BC, AB, SK combined

$Gross \ Production_{Canada,2005}$ = 2005 gross coal production of Canada

$Gross \ Production_{NS,2005}$ = 2005 gross coal production for Nova Scotia

$Gross \ Production_{NS,2004}$ = 2004 gross coal production for Nova Scotia

$Gross \ Production_{NB,2004}$ = 2004 gross coal production for New Brunswick

$Gross \ Production_{NB,2005}$ = 2005 gross coal production for New Brunswick

To allocate marketable coal production for all provinces the 2004 ratio of marketable to gross coal production is used.

Coal Cleaning

Using ratios from a report entitled *Management of Methane Emission from Coal Mines: Environmental, Engineering, Economic and Institutional Implications of Options* (Environment Canada 1990), the amount of coal cleaned was determined. British Columbia, Alberta, and Nova Scotia were the only provinces with ratios. The provincial ratio was then multiplied by the marketable coal production. Table 2.4-4 shows the 1990 ratios used. These ratios are the same as the ratios identified in Table 2.4-6.

Table 2.4-4: Ratios of Cleaned Coal Production to Raw Coal Production, by Province, for 1990[1,2]

Province/region	Ratio of cleaned coal production to raw coal production
British Columbia	0.9895
Alberta	0.3223
Nova Scotia	0.2342

Notes:

1. All other provinces and territories have a ratio of zero
2. Reference: Environment Canada (1990).

Terminals and End-Use Facilities

Activity levels for terminal and end-use facilities were prorated from 2002 using growth factors (Infometrica, 2002).

2.4.5 Comparison of 2005 Methods with Previous Methodology

The source of statistical data changed from 2003 to 2005 due to a discontinuation of providing the public with statistics by the Coal Associatiion of Canada. Therefore, the 2005 activity level procedure is different from 2003 for Coal Production. It should also be noted that the activity level procedure for 2003 and 2005 is also different from 2002 This section outlines the 2002 procedure for obtaining activity levels. If all statistical data is available, this procedure should be followed.

Coal production, capacity and technical data, coal cleaning, areas for wind erosion and the final destination of the coal were reported for each coal mine in Canada in a report entitled *Management of Methane Emission from Coal Mines: Environmental, Engineering, Economic and Institutional Implications of Options* (Environment Canada 1990). The cleaning ratios and destinations for coal given in the report were used to assist in the development of the processed quantities of coal (base quantities).

Annual marketable coal production was provided in Statistics Canada Catalogue No. 45-002-XIB (Coal and Coke Statistics) and used to estimate emissions from mining, cleaning and transportation of coal. Imported coal data from that same source were also used for the estimation of transportation emissions from the provinces of Alberta, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia and Newfoundland and Labrador. British Columbia used the total quantity of coal transported as derived from Statistics Canada Catalogue No. 54-205-XIE (Shipping in Canada).

Base Quantity for Mining

For coal mining, raw coal loading, raw coal unloading and overburden removal, marketable coal production was used as a starting quantity. However, marketable coal production has to be converted to gross coal production. The ratios (gross coal to marketable coal) are given in Table 2.4-4.

Table 2.4-5: Ratios of Gross Coal to Marketable Coal for 1990[1]

Province/mines	Gross coal (Mt)	Marketable coal (Mt)	Ratio of gross to marketable coal
British Columbia			
Fording River	9.50	6.10	1.56
Greenhills	3.70	2.90	1.28
Line Creek	2.80	2.00	1.40
Quintette	9.60	4.60	2.09
Bullmoose	2.30	1.60	1.44
Elkview (Balmer)	9.60	5.60	1.71
Coal Mountain	2.20	1.50	1.47
Quinsam	0.20	0.20	1.00
Alberta			
Luscar	2.80	2.30	1.22
Gregg River	2.70	1.90	1.42
Highvale	11.90	11.70	1.02
Whitewood	2.80	2.70	1.04
Genesee	1.80	1.50	1.20
Coal Valley	3.50	1.90	1.84
Obed	2.10	1.00	2.10
Smoky River	2.30	2.10	1.10
Paintearth (+ Vesta)	3.00	3.00	1.00
Sheerness (+ Montgomery)	2.10	2.10	1.00
Saskatchewan			
Poplar River	3.80	3.80	1.00
Boundary Dam/Shand (Utility)	3.40	3.40	1.00
Bienfait	1.50	1.50	1.00
Costello	0.60	0.60	1.00
New Brunswick			
Minto	0.50	0.50	1.00
Nova Scotia			
Prince	3.90	3.30	

Note:
1. Reference: Environment Canada (1990).

Base Quantity for Coal Cleaning

The 1990 ratio of cleaned coal to raw coal production was applied to the inventory year considered for each province and mine (see Table 2.4-5). The amount of raw coal produced was multiplied by this ratio to obtain the "coal cleaned production" for that year. Raw coal production information is available from Statistics Canada Catalogue No. 45-002-XIB (Coal and Coke Statistics), Table 1. Ratios of coal cleaned are seen in Table 2.4-6 and are the same ratios seen in Table 2.4-4

Table 2.4-6: Ratios of Cleaned Coal Production to Raw Coal Production, by Province, for 1990[1,2]

Province/region	Ratio of cleaned coal production to raw coal production
British Columbia	0.9895
Alberta	0.3223
Nova Scotia	0.2342

Notes:
3. Newfoundland and Labrador, Prince Edward Island, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Yukon and the Northwest Territories have a ratio of 0.
4. Reference: Environment Canada (1990).

2.4.6 Alternative Methods Used by Provinces/Territories

]There were no alternative methods used for any province or territory

2.4.7 References

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U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Section 11.9: Western Surface Coal Mining. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/index.html)

2.4.8   Guidebook Sector Documentation Record

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INDUSTRIAL SECTOR

2.5   CONCRETE INDUSTRY 2006

2.5.1   General Description

The concrete sector's geographic distribution closely follows economic activity, since concrete cannot be transported over long distances. It is generally concentrated in areas with the most manufacturing and construction. Ontario and Quebec accounts for the majority of production, with the prairie provinces also taking a significant proportion. The remainder is spread across the other provinces and territories.

2.5.2   Sector Description

Concrete is composed essentially of water, cement, fine aggregate (i.e., sand) and coarse aggregate (i.e., gravel, crushed stone or iron blast furnace slag). Concrete batching plants store, convey, measure and discharge these constituents into trucks for transport to a job site or to a process for use in the manufacturing of concrete pipe, concrete blocks, etc. Particulate matter is the only pollutant addressed here for this aspect of the cement/concrete sector. Transportation-related emissions are addressed in chapter 4 of this guidebook.

Raw materials for a concrete plant may be delivered by rail, truck or barge. The cement is transferred to elevated storage silos pneumatically or by bucket elevator. The sand and coarse aggregate are transferred to elevated bins using a front end loader, clamshell crane, belt conveyor or bucket elevator. These constituents are then proportioned from the storage bins by means of weigh hoppers.

At most batch plants, the sand, coarse aggregate and cement are gravity fed from the weigh hopper into a transit-mix truck, where water is added. The batch product is transported (and mixed simultaneously) to construction sites for building purposes. In central mix plants, the concrete is mixed at the plant and then delivered to the job site.

For concrete products, concrete is mixed using similar methods and then used in subsequent moulding/forming product steps.

Most particulate matter emissions from these plants are fugitive in nature. Fugitive sources include material transfer, loading and unloading, vehicle traffic and wind erosion from storage piles. Fugitive emissions control varies from plant to plant.
The only controllable source, the transfer of cement to the silo, is usually vented to a fabric filter or sock.

2.5.3 Inventory Method

Concrete batch plants are inventoried as point sources and area sources of particulate matter. Emission factors based on the mass of materials mixed are used (Table 2.5-1). The uncontrolled particulate emission factors were taken from the 5th edition of AP-42, section 11.12 (U.S. EPA 1998). For sand and aggregate transfer a weighted combination of 2 emission factors were used based on each material's proportion in concrete. The PM_{10} and $PM_{2.5}$ emission factors were derived from the TPM emission factor, using information from the PM Calculator program from the U.S. EPA (SCC 30501101):

PM_{10} EF = 0.51 · TPM EF
$PM_{2.5}$ EF = 0.15 · TPM EF

Table 2.5-1: Particulate Emission Factors for the Ready-Mixed Concrete Industry

Sources	Emission factors (kg/t of materials mixed)		
	TPM	PM_{10}	$PM_{2.5}$
Sand and aggregates transfer	0.0025	0.0012	0.0003
Cement unloading	0.3600	0.1836	0.0540
Weigh hopper loading	0.0026	0.0013	0.0004
Loading mixer	0.2720	0.0670	0.0165
Loading truck	0.4980	0.1390	0.0465

Heavy metal emission factors were also obtained from the AP-42 (US EPA 1998) for the loading truck source. These emission factors are shown in Table 2.5-2

Table 2.5-2: Heavy Metal Emission Factors for the Ready-Mixed Concrete Industry

Sources	Emission factors (kg/t of materials mixed)		
	Hg	Cd	Pb
Loading truck	0	0.0000000171	0.00000181

2.5.4 Activity Level

Due to a lack in activity levels for 2006, therefore 2005 calculated activity levels were used.

National production figures of cement for the year 2005 were taken from the Natural Resources Canada website for Minerals and Mining Statistics On-Line (2005). This data can also be taken from the Canadian Minerals Yearbook, if available. From a total of 14,922,000 tonnes of cement produced, it is assumed that 74.7% is used for domestic concrete production (CANMET 1993). The composition of concrete is calculated to be 80.46% aggregates and 11.55% cement, on average, based on information in the 1993 CANMET report.

The 1993 CANMET report also provided 1991 regional and provincial/territorial concrete production distributions (Table 2.5-3). These regional distributions were further broken down using Statistics Canada 2005 populations (Table 2.5-4) to allocate the national concrete production to each province and territory.

Table 2.5-3: Regional and Provincial Concrete Production Distributions of National Concrete Production

Region/Province	Percent Distributed
Atlantic Provinces	6%
Quebec	27%
Ontario	34%
Prairies	17%
British Columbia and Territories	16%

Table 2.5-4: Provincial Concrete Production Distributions of Regional Concrete Production

Region	Provinces/Territories Included in Region	Percent Distributed
Altantic Provinces	Newfoundland	22.01%
	Prince Edward Island	5.89%
	Nova Scotia	40.01%
	New Brunswick	32.08%
Prairies	Manitoba	21.69%
	Saskatchewan	59.99%
	Alberta	18.31%
British Columbia and Territories	British Columbia	97.61%
	Yukon	0.71%
	Northwest Territories	0.99%
	Nunavut	0.69%

2.5.5 Comparison of 2005 Methods with Previous Methodology

There were no changes in methodology from the 2002 inventory for this sector.

2.5.6 Alternative Methods Used by Provinces/Territories

There were no alternative methods used by the provinces.

2.5.7 References

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 (www.epa.gov/ttn/chief/ap42/index.html)

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INDUSTRIAL SECTOR

2.6   FERROUS FOUNDRIES 2006

2.6.1   General Description

In 2005, the majority of open hearth ferrous foundries were found in Ontario, with moderate activity in Quebec. Electric arc foundries are primarily found in Ontario, with minor activity in Manitoba, Quebec and British Columbia. Quebec has the largest activity in induction foundries, with relatively moderate activity in Ontario, Manitoba and British Columbia. No foundries of any type have been identified in Newfoundland and Labrador, Prince Edward Island, Yukon or the Northwest Territories.

2.6.2   Sector Description

Ferrous foundries include facilities for the production of castings of various types of ferro-alloys and small iron and steel foundries not associated with integrated iron and steel facilities.

Grey iron foundries produce grey iron castings from scrap iron, pig iron and foundry returns by melting, alloying and moulding (U.S. EPA 1985).

Steel foundries produce steel castings by melting, alloying and moulding pig iron and steel scrap (U.S. EPA 1987).

Particulate matter and CO are the main criteria air pollutants emitted, although lesser amounts of SO_x, NO_x and VOCs are also emitted from certain process operations (Environment Canada 1983; U.S. EPA 1985).

The major production steps of grey iron or steel foundries are raw materials handling and preparation, metal melting, mould and core production, and casting and finishing.

The raw materials handling operations include receiving, unloading, storing and conveying (using trucks, loaders and/or conveyors) of all raw materials for both furnace charging and mould and core preparation. Raw materials may be stored in open piles or enclosed storage areas. Raw materials are as follows (U.S. EPA 1985):

	Grey iron foundries	Steel foundries
metallic	pig iron	pig iron
	iron and steel scrap	iron and steel scrap
	foundry returns	foundry returns
	metal turnings	metal turnings
		alloys
		carbon additives
fluxes	limestone	limestone
	dolomite	soda ash
	fluorspar	fluorspar
	calcium carbide	calcium carbide
moulding and casting	sand	sand
	sand additives	sand additives
	binders	binders
fuels	coke, coal	coke, coal
	oil and/or natural gas	oil and/or natural gas

Melting of iron or steel metallics and flux charge are done in one of four main types of furnaces: cupola, induction, electric arc or reverberatory. In some cases, scrap may be prepared prior to charging by solvent degreasing or heating (Environment Canada 1983; U.S. EPA 1985).

Electric arc furnaces, the most common furnace used in steel foundries, are charged with raw materials by removing the lid, through a chute opening in the lid or through a door in the side. Molten metal is tapped by tilting and pouring through a hole in the side. Slag is removed through a slag door (U.S. EPA 1985).

The cupola, the main type of furnace used in grey iron foundries, is the only furnace to burn coke as a fuel. The cupola is charged at the top with alternating layers of coke, metallics and fluxes. Iron is melted by the burning coke, and the flux removes impurities in the iron to form slag. Both the molten iron and the slag are removed through tap holes at the bottom of the cupola (U.S. EPA 1985).

Further details on all of these furnaces are provided in AP-42 (U.S. EPA 1985, 1995).

Moulds, which are forms used to shape the casting exterior, are made of wet sand with clay and organic additives, dried with hot air. Cores, which are forms used to make the internal voids in castings, are made of sand with organic binders, moulded into a core and baked in an oven. Used sand from castings shakeout operations is recycled to the sand preparation area, where it is cleaned, screened and reused (U.S. EPA 1985).

After the metal is tapped, usually into a ladle, it may be treated and is then poured into moulds. When partially cooled, the castings are placed on a vibrating grid and the mould

and core are shaken away from the casting. After the casting is completely cooled, any burns, risers and gates are broken or ground off. The casting is then usually shot-blasted or tumbled to remove any remaining mould sand and scale (U.S. EPA 1985).

Particulate matter is emitted from raw materials handling operations. These emissions may be controlled by enclosing major emission points and routing the air from the enclosures through fabric filters or wet collectors (U.S. EPA 1985).
Scrap preparation with solvent degreasing results in the emission of hydrocarbons. Emissions from scrap preparation with heat include smoke, organics and CO. Catalytic incinerators and afterburners can control about 95% of organic and CO emissions (U.S. EPA 1985).

Emissions from melting furnaces include particulate matter, CO, VOCs, SO_2 and NO_x, although SO_2 emissions are characteristic of cupola furnaces and are attributable to sulfur in the coke. The highest concentrations of furnace emissions occur during charging, backcharging, alloying, oxygen lancing (in the case of steel), slag removal and tapping operations, because furnace lids and doors are opened. If uncontrolled, emissions escape into the furnace building and are vented through roof vents. Emission controls for melting and refining usually involve venting the furnace gases and fumes directly to a control device. Fugitive furnace emissions control includes canopy or special hoods near the furnace doors and tapping hoods to route emissions to control systems (U.S. EPA 1985). An Environment Canada (1983) survey found that, in Canada, a variety of control equipment was used in melting operations. For instance, scrubbers and wet caps were commonly installed on cupolas with afterburners for CO control, although cyclones and sometimes baghouses were also used. Collector units used on electric arc furnaces were baghouses and scrubbers. Emissions from induction and reverberatory furnaces were normally uncontrolled.

The major pollutants from mould and core preparation are particulate matter, CO and VOCs. Baghouses and high-energy scrubbers may be used to control particulate matter emissions. Afterburners and catalytic incinerators may be used to control VOC and CO emissions.

Emissions from casting include particulate matter, CO and VOCs. Emissions from pouring are usually uncontrolled, although they may be vented. Emissions of particulate matter during shakeout are usually collected and controlled by either high-energy scrubbers or bag filters.

Finishing operations result in the emission of particulate matter, which may be controlled by cyclones or baghouses.

2.6.3   Inventory Method

No ferrous foundry emission factors were used for 2005. 2005 emissions were prorated from 2004 emissions using Informetrica (2002) growth factors. These emissions were used in 2006.

In 2000, Ferrous foundry emissions were calculated using particulate, SO_x, NO_x, VOC and CO emission factors for open hearth, electric arc and induction furnaces, assuming no process control (U.S. EPA 1990), as listed in Table 2.6-1. These emission factors are based on the tonnes of metal melted, rather than tonnes of castings produced. The PM_{10} and $PM_{2.5}$ emission factors were taken from the PM Calculator program from the U.S. EPA.

Table 2.6-1: CAC Emission Factors for Ferrous Foundries

Process	Emission factors (kg/melted tonne)						
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO
Open hearth (cupola)	6.2000	5.9520	5.8280	0.0018	0.0500	0.0900	72.5000
Electric arc	5.8000	5.2258	4.8720	0.1250	0.3000	0.1500	9.5000
Induction	5.8000	5.2200	3.7700	0.1250	0.3000	0.1500	9.5000

Emission factors for heavy metals and dioxins and furans, were also collected using the US EPA's FIRE emission factor database (2004) and a report titled Draft Dioxin Reassessment (2003). These emission factors are not used but are listed in Table 2.6-2.

Table 2.6-2: Toxic Emission Factors for Ferrous Foundries

Process	Emission factors			
	Hg (kg/tonne)	Cd (kg/tonne)	Pb (kg/tonne)	D/F (ng/kg)
Open hearth (cupola)	0.000174	0.000476	0.300000	1.26
Electric arc			0.027250	1.26
Induction	0.000036	0.001654		1.26

2.6.4   Activity Level

No activity levels were used, the pro-rated 2005 emissions were used in 2006.

2.6.5   Comparison of 2006 Methods with Previous Methodology

There were no changes to the methodology however due to lack in activity levels, 2005 data was used.

2.6.6   Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces for this sector.

2.6.7   References

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2.6.8   Guidebook Sector Documentation Record

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Author: Lynn Nadon, Pollution Data Division

INDUSTRIAL SECTOR

2.7   GRAIN INDUSTRIES

2.7.1   General Description

Grain elevators are primarily transfer and storage units. They are divided into four groups based on their location and function: primary, process, transfer and terminal elevators.

Primary elevators are located in the major grain-producing areas of Alberta, British Columbia, Saskatchewan and Manitoba.

Although there has been a steady decline in the number of primary elevators since the late 1960s, a sharp increase in average elevator capacity is indicative of the trend towards the large land terminal elevators in Western Canada. (Canadian Agriculture at a Glance, Statistics Canada, Catalogue no. 96-325-XPB)

2.7.2   Sector Description

Particulate matter is the only pollutant inventoried from this sector.

Primary elevators receive grain by truck from producers for either storage or forwarding. These elevators sometimes clean or dry grain before it is transported to terminal or process elevators (U.S. EPA 1985).

Terminal elevators dry, clean, blend and store grain for shipment to transfer, other terminal (for export) or process elevators.

Transfer elevators generally perform the same function as terminal elevators.

At any grain elevator, the first step is the unloading of the grain from the incoming truck, rail car or barge into a hopper. The grain is then transferred to the main part of the elevator, the headhouse, by a conveyor. In the headhouse, grain is lifted on an elevator leg and discharged on a gallery belt. The gallery belt transfers the grain to storage, where a tripper diverts the grain into the proper bin or silo. Grain is typically cleaned and/or dried before storage. Grain is discharged from storage to loadout via tunnel belts that run below the bins (U.S. EPA 1985).

Process elevators are actually grain processing plants or mills. While the elevator operations of unloading, conveying and storing are performed at these locations, they also include direct manufacturing or processing of grain for use in other products. The principal function in this regard is milling (U.S. EPA 1985).

Significant particulate emission sources for grain handling operations include grain dryers and cleaners. The amount of dust emitted during the various operations depends upon the type of grain being handled, its quality or grade, its moisture content, the degree of enclosure at loading and unloading areas, and the extent and efficiency of dust containment systems used. Process elevators have additional particulate emissions from the milling operations (U.S. EPA 1985).

Some processes in grain elevators are evacuated through pollution control equipment such as fabric filters and cyclones. The efficiency of these devices influences the PM emissions from the process. In past inventories general control assumptions of 75% for cyclones (assumed to be used at Primary elevators) and 90% for fabric filters (assumed to be used at terminal and transfer elevators. (P.E.L.)

2.7.3   Inventory Method

In 2006, Pinchin Environmental Ltd. was commissioned to improve the CAC emissions estimates from the grain handling industry. This detailed report provided new emission factors and methodologies which greatly reduced the previously calculated emissions. It was concluded that the P.E.L. estimations are thorough, accurate and up to date and would therefore be used in the CAC inventory.

In 2006 the estimated emissions from the P.E.L. report were used. Please see "CAC Emissions from the Canadian Grain Handling Industry – 2006" for details on emission factors calculations. The calculated emission factors for the four types of grain elevators from the P.E.L. are as follows.

Table 2.7-1: Emission Factors for Primary Elevators Emissions

Processes	Emission Factors			Control	Handling
	TPM	PM10	PM2.5	Efficiency	Ratio
	(kg/tonne)	(kg/tonne)	(kg/tonne)		
Receiving (Straight Truck)	0.09	0.0295	0.005	0	1
Shipping (Rail Car)	0.0135	0.0011	0.000185	0	1
Cleaning	0.0375	0.0095	0.0016	-(1)	0.5
Drying	1.5	0.375	0.065	75% (2)	0.5
Transfer Conveying	1.4	0.347	0.05899	75%	
Headhouse	2.25	0.35	0.0595	75%	

For primary elevators, it was assumed that grain would be handled once in Shipping, Receiving and that there are no controls at shipping and receiving. Receiving was assumed from straight trucks and Shipping was assumed to be by railcar. Hopper bottom trucks are increasing in use and a change in the receiving factor may be warranted in the future. Based on industry trends, it was assumed that 50% of all grain handled at primary elevators is cleaned and dried at the elevator (hence the handling ration of 0.5). The cleaning factor in AP42 is after a cyclone control. Factors for transfer and conveying are older WEBFIRE factors that are based on tonnes shipped or received and therefore

the handling ratio in assumed in the factor itself (in this case it is 2). The same goes for the headhouse factor, which assumes a factor of 3. PEL did not use the new AP-42 factors for transfer and conveying because they are substantially lower that the WEBFIRE factors and it is recommended that the move to the lower factors be based on a better survey of the state of Western Primary Elevators.

Table 2.7-2: Process Elevator Emission Factors

Processes	Emission Factors			Control	Handling
	TPM	PM10	PM2.5	Efficiency	Ratio
	(kg/tonne)	(kg/tonne)	(kg/tonne)		
Receiving	0.05375	0.0167	0.002825	75%	1
Precleaning & Handling	0.0375	0.0095	0.0016	-(1)	1
Cleaning House	0.0375	0.0095	0.0016	-(1)	1
Mill House	35	17.5	2.975	97%	1

At process elevators, receiving of grain was assumed to be from 50% hopper bottom and 50% straight truck. Receiving emissions are assumed to be controlled by a cyclone. For the Canadian grain emissions estimates, it has been assumed that all process elevators are associated with millhouses. However, millhouse emission factors are not listed under the AP-42 grain elevator emission factors. Millhouse emission factors were found in WebFIRE, the factor for wheat milling was assumed for all process elevators (the range of factors was fairly small). Emission factors for PM2.5 were not available for millhouses and these values (controlled and uncontrolled) were approximated by applying a factor of 0.17 to the PM10 values as per AP-42 Table 9.1.1.1.

Table 2.7-3: Transfer Elevator Emission Factors

Processes	Emission Factors			Control	Handling
	TPM	PM10	PM2.5	Efficiency	Ratio
	(kg/tonne)	(kg/tonne)	(kg/tonne)		
Shipping & Receiving	0.099	0.025	0.0036	90%	1
Transfer Conveying	0.0125	0.0032	0.0006	90%	1.2
Headhouse	0.0305	0.017	0.0029	90%	2.2

For transfer elevators, shipping and receiving were assumed to be by ship. The handling ratios proposed by Benjamin were maintained and all emissions are assumed to be controlled by fabric filter with 90% efficiency. All factors were based on new AP-42 factors. Transfer and Terminal elevators are located in ports and close to urban areas, where scrutiny from public and regulators will be more intense. For this reason the lower factors were assumed to be appropriate.

Table 2.7-4: Emission Factors for Primary Elevators Emissions Factors

Processes	Emission Factors			Control	Handling
	TPM	PM10	PM2.5	Efficiency	Ratio
	(kg/tonne)	(kg/tonne)	(kg/tonne)		

Shipping & Receiving	0.04	0.0099	0.0017	90%	1
Transfer Conveying	0.0125	0.0032	0.0006	90%	2
Cleaning	0.0375	0.0095	0.0016	-(1)	0.5
Drying	1.5	0.375	0.065	90%	0
Headhouse	0.0305	0.017	0.0029	90%	3

At terminal elevators it was assumed that all processes were controlled at 90% efficiency except cleaning, which is based on cyclone control. Handling ratios were reduced (from Benjamin) to reflect the fact that more services are being performed at primary elevators. It was assumed that in 2006, no drying took place at terminal elevators; this was confirmed by discussion with Greater Vancouver Regional District (GVRD) 17. Also it was assumed that 50% of grain throughput was cleaned at the terminal, this is slightly lower that reported by GVRD, which estimate 90% of grain was cleaned in 2005 at the Vancouver terminals. As stated above, Terminal elevators are located in ports and close to urban areas, where scrutiny from public and regulators will be more intense. For this reason the new AP-42 factors were selected, which is in line with the practice of the GVRD.

The emission factors are then multiplied by the activity level for each province in order to obtain the appropriate emissions levels.

Sample Calculation:
Emission Rate = Aggregate throughput x 1000 tonnes/kilotonne x emission factor ÷ 1000 kg/tonne x (100% - control efficiency) x handling ratio

2.7.4   Activity Level

Throughput data are derived from Canadian Grain Commission data for licensed grain elevators. Crop year (Aug1-July31) for years 2005, 2006 and 2007 were used to develop a 2006 calendar year throughput. Specific CGC documents used were: Grain Statistics Weekly for Crop Year 2005-2006 - Weeks 21&22; Crop Year 2005-2006 Week 52; Crop Year 2006-2007 - Weeks 21&22. CGC does not license any Eastern primary or process elevators. Data are only available for Western Elevators and Eastern Terminal and Transfer Elevators.   The total eastern Canadian grain throughput was calculated by subtracting the total western Canada throughput from the total Canadian throughput (values are from Cereals and Oilseeds Review. Statistics Canada Catalogue no. 22-00-7-XI. It was assumed that all Eastern primary elevators were located in Ontario. The impact of primary elevators that may exist in other eastern provinces is expected to be negligible. The distribution of Process Elevator throughputs and Transfer Elevator throughputs is from Environment Canada's 1995 inventory.

2.7.5   Comparison of 2006 Methods with Previous Methodology

New activity levels and methodology have been derived from the P.E.L. study.

2.7.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces for this sector.

2.7.7 References

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2.7.8 Guidebook Sector Documentation Record

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Author: Martin Savard, P.E.L Study, Pollution Data Division

INDUSTRIAL SECTOR

2.8   MINING AND ROCK QUARRYING 2006

2.8.1   General Description

In Canada, in 2005, over 72, 980 kt of ore and rock were mined in open pit mines and quarries and 124, 219 kt in underground mines.

Underground metallic ore mining was concentrated in New Brunswick, Quebec and Ontario, with Manitoba, Saskatchewan, British Columbia and the Northwest Territories accounting for the remaining 30%. Open pit metallic ore mining was largely concentrated in British Columbia at 59%, with Quebec and Ontario accounting for the remaining 41% of the total mass of ore produced.

Ontario was the largest producer for non-metallic underground mining at 70%, with Saskatchewan at 11% of the production total for Canada. Limestone was the most commonly mined substance for open pit non-metallic mining, followed by granite and sandstone.

2.8.2   Sector Description

The inventory methods described in the next section are generally common to a large number of different product industries and sectors in which mining, crushing and raw material preparation are accomplished in a similar manner. In most instances, particulate matter (of predominantly coarse size) is the primary pollutant.

Emissions from sand and gravel production, silica production and stone processing have been included in separate sections (sections 2.9, 2.10 and 2.11, respectively).

Emissions from the use of fuel by this sector are accounted for in the industrial fuel combustion (section 2.15) and off-road vehicles and engines (section 4.2) sectors.

This sector encompasses mining and quarrying aspects (but not necessarily further processing) of the following minerals and aggregates: non-ferrous and precious metals, gypsum, limestone, stone and other ores or aggregates. Summaries are given of the principal techniques used in this sector.

Open Pit Mining and Quarrying

In rock quarrying and open pit mining, some or all of the following operations are done prior to further processing: overburden removal, drilling in rock or ore bodies, blasting, loading of materials, transporting raw materials by conveyors or haulage trucks, scraping, bulldozing, grading, etc. These operations represent uncontrolled open sources of

generally coarse-sized fugitive dust, some of which are relatively minor sources. When necessary, dust suppression methods (e.g., watering) may be used. The major fugitive dust sources, also associated with the mining operations, are often reported to be blasting (where done frequently), hauling of materials by truck, bulldozing, open storage pile losses and wind erosion from exposed areas (U.S. Bureau of Mines 1985; U.S. EPA 1985). The extent of emissions, which can be highly variable, depends on general sets of parameters, such as:

- the extent of source activity;
- properties of material disturbed;
- implementation of dust control measures; and
- climatic conditions.

Depending on the industry, further processing (e.g., sizing or separation of the mineral value from rock) may be done at the mine site or a separate processing plant.

Underground Mining

Both non-metal and hard rock metal mining may be done underground to extract the mineral from seams. In addition to further processing, mining operations typically involve drilling or boring, blasting, crushing, loading and conveying ores through shafts and to the surface. The amount of particulate matter released to the atmosphere is naturally lower from underground mines than from open pit mines, but particulate matter can nevertheless be emitted through the ventilation systems. Again, fugitive emissions can occur from material haulage and open storage piles.

Crushing and Screening

Crushing operations are common to all mining and mineral processing facilities, in order to either size materials or separate valuable minerals from the gangue or rock matrix. In the mineral processing industries, ore from the mines or quarries is reduced in size in various stages to achieve mineral separation, with the amount of crushing depending on the nature of the ore and processing requirements. Individual primary, secondary and sometimes tertiary crushing operations will often include equipment components, such as hopper, screen, crusher, surge bin, apron feeder and conveyor belt transfer points. Where controls are implemented, emissions from these various components are usually ducted to a single control device (e.g., wet scrubber or baghouse) (U.S. EPA 1985). Where necessary, final size reduction is usually accomplished by grinding in rod or ball mills. The ore is often ground in a water slurry to result in negligible particulate emissions, while in some dry grinding, magnetic separation or air classification/conveying processes (e.g., some iron ore beneficiation facilities), particulate emissions can be significant. Dry cyclones are normally used for grinding operations involving air conveying and air classification. Dust can also be generated during material transfer operations (e.g., conveyor belt transfer points). Further ore beneficiation and recovery by physical or chemical separation are usually done in aqueous solution, whereby essentially no particulate emissions can be expected. Stone processing is inventoried under section 2.11.

Drying

Concentrated mineral products, such as lead concentrate after flotation, may be dried to remove surface moisture. Although various types of units may be employed, natural gas-fired rotary dryers are most frequently used (U.S. EPA 1985). Both particulate emissions and gaseous combustion products are released. The gaseous combustion products are inventoried as part of the industrial fuel combustion sector (section 2.15).

Note that this sector is concerned with the mechanical processes required for the mining or ore and rock. Further processing to develop concentrated mineral products is beyond the scope of this sector. As such "*Concentrate Drying*" and "*Concentrate Transport*" are not included in this sector.

2.8.3 Inventory Method

Emissions of total particulate matter, PM_{10} and $PM_{2.5}$ from underground mining, open pit mining and concentrate drying and transport were calculated by pro-rating emissions from the year 2004 using growth factors based on the December 2005 CAC forecast. Due to a lack in data, the 2005 data was used for the 2006 report without proration.

For the years 2004 and earlier emissions were calculated using the emission factors in Table 2.8-1. Emission factors for all mining sources come from the US EPA's AP-42 (1995).

Table 2.8-1: Mining and Quarrying Emission Factors for Particulate Matter

Source description	Emission factors (kg/t)		
	TPM	PM_{10}	$PM_{2.5}$
Underground mining	0.0500	0.0040	0.0005
Open pit mining	0.5100	0.0408	0.0051
Concentrate transportation	5.0000	0.5000	0.0500
Concentrate drying	3.4981	0.3498	0.0350

Particulate emissions for stone quarries use the same emission factors as open pit mining, as seen in Table 2.8-1.

2.8.4 Activity Level

2005 Activity levels are calculated using the division of pro-rated emissions by the emission factors. In 2006, the 2005 data was used for calculating emissions.

2.8.5 Comparison of 2005 Methods with Previous Methodology

For the compilation year of 2003, activity levels were found from various statistical sources. In general, data from Statistics Canada and the Canadian Minerals Yearbook series were used as sources for ore production and mine production figures. In some

cases, the provincial/territorial distributions were calculated based on distributions provided in the Canadian Minerals Yearbook.

Specifically, data for ore production was provided, at a national level, in Table 7 from Statistics Canada Catalogue No. 26-223-XIB. This data was available under three distinct classifications: precious metal ore, iron ore and other ore. Precious ores include non-ferrous ores, such as copper, nickel, lead, zinc and common precious ores (gold and silver). Iron ore mining is inventoried using point source techniques in a separate sector. "Other metals" include antimony, bismuth, cadmium, cobalt, germanium, molybdenum, platinum, selenium, tantalum, tellurium, tin and uranium.

Provincial estimations of the kilotonnes of ore removed were determined using national and provincial metallic mineral production ratios that were based on Table 10 from Statistics Canada Catalogue No. 26-223-XIB. These ratios were then applied to the national ore production data from Table 7 to arrive at the distribution of the ore production activity data by province.

A similar methodology was followed for non-metallic mineral mining, whereby the 2003 national kilotonnes of ore hoisted for asbestos, gypsum, salt, potash and other non-metallics were taken from Table 6 in Statistics Canada Catalogue No. 26-226-XIB. This data was then disaggregated into the tonnes of ore by province using national and provincial metallic mineral production ratios that were based on Table 9 from Statistics Canada Catalogue No. 26-226-XIB.

The total metallic and non-metallic ore mined data was then divided into open pit and underground mining using information from the Mining and Mineral Statistics Online (2005).

Stone quarries fall into a separate category. The 2003 provincial/territorial productions in kilotonnes for limestone, marble, granite, sandstone and shale were taken from the Canadian Minerals Yearbook. All quarries have open pit operations.

Finally, the activity levels for the stone quarries for the Northwest Territories were distributed between the Northwest Territories and Nunavut based on the populations of these territories in 2003.

2.8.6   Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces/territories.

2.8.7   References

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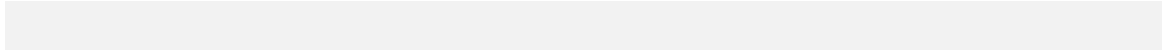
INDUSTRIAL SECTOR

2.9   SAND AND GRAVEL PRODUCTION 2005

2.9.1   General Description

Sand and gravel are used for road construction, as an aggregate for asphalt and concrete and for other construction purposes, such as for fill and for mortar sand. Sand is also used in the glassmaking, foundry and abrasives industries. Ontario is the largest producer of sand and gravel, followed by Alberta and Quebec.

2.9.2   Sector Description

Sand and gravel deposits are quarried, transported to the plant and then classified and stockpiled. Many sand and gravel plants operate intermittently to supply local Canadian markets. As for other mineral aggregates, processing is accomplished by crushing, screening, washing, blending and stockpiling materials according to product specifications. Most process dust is reported to result from crushing operations and would normally settle at or close to the facility. However, at many plants, a substantial portion of the initially screened feed bypasses any crushing operations and is conveyed directly to wet processing operations, where negligible air emissions are expected. Similarly, because many of the materials are moist when handled, particulate emissions are expected to be significantly lower than for similar crushed stone operations. Thus, only limited emission control equipment, such as application of wet sprays, is expected to be used. The most important sources of dust at gravel pits and processing plants are wind-blown active/inactive storage pile losses and vehicular traffic on unpaved roads. These are usually seasonal fugitive emissions dependent upon local climatic conditions and can be controlled by dust suppression methods, windbreaks as well as product covers and enclosures.

Fuel combustion emissions associated with these operations are inventoried as part of industrial fuel combustion (section 2.15).

2.9.3   Inventory Method

Emission factors (Table 2.9-1) based on annual sand and gravel production in tonnes were used to estimate area source emissions from this sector. These emission factors are a composite emission factor representing the general activities in sand and gravel quarries (Vandergrift 1976). The PM_{10} and $PM_{2.5}$ emission factors were calculated using the following equations taken from the U.S. EPA's PM Calculator:

$$EF_{PM10} = 0.51 EF_{TPM}$$
$$EF_{PM2.5} = 0.15 EF_{TPM}$$

Table 2.9-1: Emission Factors for Particulate Emissions from Sand and Gravel Production

Source	Emission factors (kg/t production)		
	TPM	PM$_{10}$	PM$_{2.5}$
Sand and gravel operations	0.0500	0.0255	0.0075

2.9.4   Activity Level

No activity levels were available for 2006, 2005 data was used.

The 2005 provincial sand and gravel production data was taken from the Natural Resources Canada website for Mineral and Mining Statistics On-Line (2005). Production data for the provinces of Prince Edward Island and Nova Scotia were confidential. Their production amounts were estimated using the difference of the known values from the Canada total and then distributing using population data from Statistics Canada catalogue number 91-213, table 1.1 .

2.9.5   Comparison of 2005 Methods with Previous Methodology

There were no changes in methodology.

2.9.6   Alternative Methods Used by Provinces/Territories

No alternative methods were used by other provinces and territories.

2.9.7   References

Gibson, R. 1998. British Columbia Inventory of Common Air Contaminants Emitted in 1995 from Miscellaneous Area Sources Outside of the Lower Fraser Valley. Prepared for Air Resources Branch, B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. January.

Natural Resources Canada. Annual. Canadian Minerals Yearbook.
(www.nrcan.gc.ca/mms/cmy/index.htm)

Natural Resources Canada. 2005. Minerals and Mining Statistics On-Line – Mineral Production of Canada, by Province and Territory (http://mmsd1.mms.nrcan.gc.ca/mmsd/production/production_e.asp)

Statistics Canada. Annual. Non-Metallic Mineral Mining and Quarrying. Catalogue No. 26-226-XIB.

Statistics Canada. Annual. Annual Demographic Statistics. Catalogue No. 91-213.

U.S. EPA. 1998. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition, Supplement B. Section 8.19. Tables 2-4 and

2-5. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/oldeditions.html)
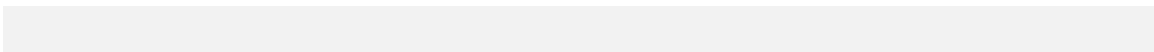
Vandergrift, A.E. 1976. Particulate Pollutant System Study. Volume 3. National Technical Information Service, U.S. Department of Commerce.

2.9.8   Guidebook Sector Documentation Record

Release Version: 1

Date: April 2008

Author: Lynn Nadon, Pollution Data Division

INDUSTRIAL SECTOR

2.10   SILICA PRODUCTION 2003

2.10.1 General Description

Silica sand (i.e., 90–99% quartz) is quarried mainly for use by the glass industry and in refining and smelting. It is also used in casting sand in foundries, abrasives, fibreglass production and sandblast industries. Most is produced in Quebec, Ontario and Alberta.

2.10.2 Sector Description

Industrial sand processing operations are similar to those of construction sand production involving crushing/screening and may include wet milling, flotation, drying, air classification and cracking of sand grains to form very fine products. Dust emissions originate mainly from the crushing and screening operations, especially when grinding to very fine particle sizes (e.g., silica flour). Dry or wet screening and air classification may be practised to achieve the desired size distribution. Both wet and dry methods of dust control are used, and baghouses are most commonly used.

2.10.3 Inventory Method

Emission factors (Table 2.10-1) based on annual coarse or fine silica production were used to estimate area source emissions from this sector. The particulate emission factors are from Section 11.19.2 of AP-42 (U.S. EPA 1995) and are for controlled emissions from primary crushing, secondary crushing, screening, recrushing (coarse only), fine mills (coarse only), conveying and handling and storage pile losses. The PM_{10} and $PM_{2.5}$ emission factors were calculated using the U.S. EPA's PM Calculator:

$$EF_{PM10} = 0.098 EF_{TPM}$$

$$EF_{PM2.5} = 0.029 EF_{TPM}$$

Table 2.10-1: Emission Factors for Particulate Emissions from Silica Production

Source/category	Emission factors (kg/t production)		
	TPM	PM_{10}	$PM_{2.5}$
Coarse production	0.9655	0.0946	0.0280
Fine production	0.6905	0.0677	0.0200

2.10.4 Activity Level

Due to a lack in activity levels the 5006 activity levels were used for 2006.

The 2005 provincial/territorial silica production data was taken from the Natural Resourses Canada website for Mineral and Mining Statistics On-Line and broken down

into coarse and fine production. In the statistics given there were 7 provinces with confidential production data. Taking the Canadian production total and subtracting the known production amounts from it resulted in a remaining production amount. The remaining production amount was then distributed among the 7 provinces based on 2005 populations from Statistics Canada 91-213.

Annual provincial/territorial silica production data, divided into coarse and fine tonnages, was available in the Canadian Minerals Yearbook for up to and including the year 1993. The size fraction percent values applied in the inventory development are given below in Table 2.10-2.

Table 2.10-2: Fine and Coarse Percentages of Production and Final Activity Level of Silica Production

Province/territory	Fine and coarse production ratio (%)
Newfoundland and Labrador	100% coarse
Prince Edward Island	100% coarse
New Brunswick	100% fine
Nova Scotia	100% fine
Quebec	41% fine
	59% coarse
Ontario	35% fine
	65% coarse
Manitoba	100% coarse
Saskatchewan	100% coarse
Alberta	100% fine
British Columbia	100% coarse
Yukon	100% coarse
Northwest Territories	100% coarse
Nunavut	100% coarse

2.10.5 Comparison of 2005 Methods with Previous Methodology

There were no changes in methodology from 2003.

2.10.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

2.10.7 References

Natural Resources Canada. 2005. Minerals and Mining Statistics On-Line – Mineral Production of Canada, by Province and Territory (http://mmsd1.mms.nrcan.gc.ca/mmsd/production/production_e.asp)

Statistics Canada. Annual. Non-Metallic Mineral Mining and Quarrying. Catalogue No. 26-226-XIB.

Statistics Canada. Annual. Annual Demographic Statistics. Catalogue No. 91-213-XIB.

U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/oldeditions.html)

2.10.8 Guidebook Sector Documentation Record

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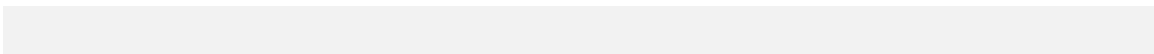
INDUSTRIAL SECTOR

2.11 STONE PROCESSING 2005

2.11.1 General Description

Although stone can be produced in a large variety of sizes (e.g., from building to pulverized stone), crushed stone accounts for the major proportion of stone production in Canada, with crushed stone for construction uses accounting for 77%. It is used mainly as an aggregate in concrete and asphalt for constructing highways, buildings and railway beds. Major rock types processed include limestone and granite, with smaller amounts of sandstone, shale and other types. Many producers are part-time or seasonal, while large operations may be associated with construction or manufacturing establishments. Building stone, also referred to as dimension stone, is primarily granite or marble used for exterior and interior building surface cladding, tiles, monuments, furniture, etc. Pulverized stone is largely used for agricultural purposes (Natural Resources Canada 2002).

Ontario and Quebec are the largest producers of stone, followed by British Columbia and Nova Scotia (Statistics Canada, 2003).

2.11.2 Sector Description

Crushed Stone

Stone processing involves the primary and secondary crushing, screening, milling and handling of stone aggregates following their removal from quarries.

Quarried stone is normally trucked to the processing plant for primary crushing (e.g., jaw, gyratory or impact crushers) and conveyed to secondary or tertiary crushers (e.g., cone, gyratory, hammer mills or roll crushers). Various screening operations are associated with crushers as size reduction occurs (e.g., inclined vibratory screens are common). Processed crushed stone is usually stored in open area stockpiles. Significant dust emissions may occur from these processing operations, depending on factors such as the rock type, feed size and reduction ratio, throughput rate, crusher type and surface moisture content of the rock. Although highly variable and only limited test data exist, greater dust emissions might be expected in successive stages of crushing as surface moisture evaporates. A large portion of the dust from such operations is of coarse size and will settle within the plant by gravity. Fugitive dust sources include re-entrainment of settled dust by wind or machine movement. The extent of particulate emission control presumably depends on the proximity of operations to populated areas. Greater use of crushing emission controls (e.g., cyclones, fabric filters, wet spray systems) and open dust suppression (e.g., wetting techniques) might be anticipated for operations located in suburban areas.

Pulverized Stone

Pulverized stone (e.g., limestone used for agricultural applications) undergoes processing similar to crushed stone but with additional crushing and screening operations to obtain finer-sized material. Depending on the rock type and desired product, tertiary crushing, grinding or milling may be done with hammer mills, rod mills or ball mills. The product is normally classified by dry vibrating screen systems or air classifiers and is conveyed/trucked to finished product bins. Both mechanical and fabric filter dust control systems might be expected to be used.

Building Stone

Rough dimension stone is usually cut from the rock face at the quarry site using drills and various combinations of diamond saws, wire saws and piercing equipment. Final cutting and finishing may be done at the quarry or at the processing plant. Dust is generated mainly by the stone cutting operations.

2.11.3 Inventory Method

2005 particulate emissions are calculated by pro-rating the 2004 emissions using growth factors that have been developed by the December 2005 CAC forecast. These pro-rated emissions were used in the 2006 inventory.

The total particulate emission factors (2.11-1) are from Section 8.19 of the 4th edition of AP-42 (U.S. EPA 1988) and Section 11.19.2 of the 5th edition of AP-42 (U.S. EPA 1995). The PM_{10} and $PM_{2.5}$ emission factors were calculated from the particulate emission factor using equations taken from the U.S. EPA's PM calculator, which vary with the emission source.

Table 2.11-1: Emission Factors for Particulate Emissions from Stone Processing

Sources	Emission factors (kg/t production)		
	TPM	PM$_{10}$	PM$_{2.5}$
Building stone	0.050 000	0.025 500	0.007 500
Crushed stone			
Drilling	0.000 800	0.000 040	0.000 002
Primary crushing	0.005 800	0.000 290	0.000 017
Secondary crushing	0.001 208	0.000 290	0.000 017
Tertiary crushing	0.001 208	0.000 290	0.000 017
Screening	0.004 286	0.000 420	0.000 124
Conveying and handling	0.007 327	0.000 720	0.000 213
Pulverized stone			
Drilling	0.000 800	0.000 040	0.000 002
Primary crushing	0.005 800	0.000 290	0.000 017
Secondary crushing	0.001 208	0.000 290	0.000 017
Screening	0.004 286	0.000 420	0.000 124
Recrushing	0.001 208	0.000 290	0.000 017
Fine milling	0.010 204	0.001 000	0.000 296
Fine screening	0.011 224	0.001 100	0.000 326
Conveying and handling	0.007 347	0.000 720	0.000 213
Storage pile losses	0.159 000	0.055 650	0.017 490
Other uses	0.060 000	0.014 400	0.000 840

2.11.4 Activity Level

2005 Activity levels are calculated using the division of pro-rated emissions by the emission factors. Due to a lack in activity levels the 5006 activity levels were used for 2006.

2.11.5 Comparison of 2006 Methods with Previous Methodology

Activity levels are not used to calculate the 2006 emissions. They are 2005 emissions which are pro-rated from 2003.

In 2003, Base quantities for provincial/territorial stone production values were derived from Statistics Canada Catalogue No. 26-226-XIB. The production value for the "crushed stone" category was assigned to each subcategory (drilling, primary crushing, secondary crushing, tertiary crushing, screening and conveying and handling). A similar process is used in the "pulverized stone" category, whereby all subcategories (drilling, primary crushing, secondary crushing, screening, recrushing, fine milling, fine screening, conveying and handling, storage pile losses and other uses) comprise the production data that were assigned to the overall "pulverized stone" category.

Within Statistics Canada Catalogue No. 26-226-XIB, building stone is equivalent to dimensional stone, and "other uses" is the combination of chemical process stone and miscellaneous stone.

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2.11.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

2.11.7 References

Natural Resources Canada. 2002. Mineral and metal commodity reviews: Mineral aggregates. In: Canadian Minerals Yearbook. (www.nrcan.gc.ca/mms/cmy/index.htm)

Statistics Canada. Annual. Non-Metallic Mineral Mining and Quarrying. Catalogue No. 26-226-XIB.

U.S. EPA. 1988. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 4th Edition, Supplement B. Section 8.19. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.
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U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.
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2.11.8 Guidebook Sector Documentation Record

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Author: Lynn Nadon, Pollution Data Division

INDUSTRIAL SECTOR

2.12   UPSTREAM OIL AND GAS INDUSTRY

2.12.1 General Description

Canada is the third largest producer of natural gas and the ninth largest producer of crude oil in the world, producing more than 20% of North America's crude oil and gas.

Most Canadian oil and gas production is from the Western Canadian sedimentary basin in Alberta, Saskatchewan and British Columbia (see Figure 2.12-1 for facility distribution). In 2000, these three provinces accounted for over 89% of Canada's total oil production and 96% of its gas production. The provinces of Manitoba, Ontario, Nova Scotia and Newfoundland and Labrador as well as the Yukon and Northwest Territories account for the rest.

Figure 2.12-1: Distribution of Larger Upstream Oil and Gas Industry Emitters in 2000
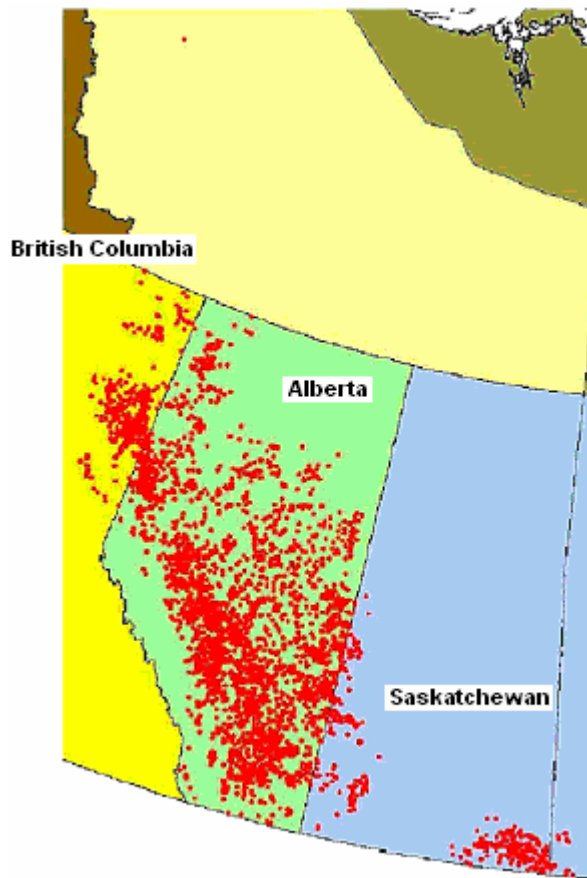
2.12.2 Sector Description

The upstream oil and gas industry includes all infrastructure used to find, produce, process/treat and transport natural gas, liquefied petroleum gas, condensate, crude oil, heavy oil and *in situ* crude bitumen to market. More specifically, the upstream oil and gas industry includes both onshore and offshore facilities, as well as drilling and exploration, conventional oil and gas production, *in situ* oilsands production, natural gas processing and oil transmission.

Although only for the reference year 2000, the current Canadian Association of Petroleum Producers (2005a, 2005b) inventory also includes contributions reported by the Canadian Gas Association (2004) for natural gas transmission, storage and distribution.

Specific segments of the industry excluded are petroleum refining, heavy oil upgrading, oilsands mining, extraction and upgrading and natural gas distribution. Emissions from construction activities, ancillary structures and operations (buildings, offices, etc.) and mobile sources are inventoried separately.

Table 2.12-1 summarizes the specific sources included in this sector.

Table 2.12-1: Classification of the Upstream Oil and Gas Industry by Industry Sector and Subcategory

Industry source sector	Industry subcategories
Drilling	Drilling fluids
	Drill-stem tests
	Drilling rigs
Well servicing and testing	Venting activities
	Service rigs
	Pumping units
	Wireline units
Gas production	Wells
	Gathering systems
	Field facilities
	Gas batteries
Light and medium crude oil production	Wells
	Flow lines
	Single-well batteries
	Satellite batteries
	Central batteries
Heavy oil and cold bitumen production	Wells
	Flow lines
	Single-well batteries
	Satellite batteries
	Cleaning plants
Thermal heavy oil and crude bitumen production	Wells
	Flow lines and gathering systems
	Satellite batteries
	Cleaning plants
Gas processing	Sweet gas processing plants
	Sour gas (flaring) plants
	Sour gas (extraction) plants
	Straddle plants
Product transmission and transportation	Natural gas systems
	Liquefied petroleum gas systems
	Pentanes-plus systems
	Crude oil systems
Waste oil reclaiming and disposal	Oilfield waste transporters
	Waste oil reclaimers
	Land treatment operations
	Road oiling
Accidents and equipment failures	Pipeline ruptures
	Well blowouts
	Spills
	Surface casing vent blows
	Gas migration to the surface

VOC emissions are contributed by all source categories; however, the main sources are storage losses, fugitive equipment leaks, venting and accidents. H_2S emissions are attributed mainly to fugitive equipment leaks, venting of waste gas streams containing low concentrations of H_2S (e.g., less than 10 ppm) and incomplete combustion of fuels and waste gas streams containing H_2S.

Gas production accounts for the majority of NO_x and CO emissions. Sour gas sulfur recovery gas processing plants are the largest contributor to SO_2 emissions, and particulate matter is largely from solution gas flaring at light/medium oil production facilities. Almost two-thirds of VOC emissions are attributed to light/medium oil production facilities and heavy oil/cold bitumen production facilities. Fuel combustion is a source of particulate, NO_x, CO and SO_2.

2.12.3 Inventory Method

The recent addition of criteria air contaminants (i.e., NO_x, SO_x, VOCs, CO, TPM, PM_{10} and $PM_{2.5}$) and H_2S to the National Pollutant Release Inventory in Canada has stimulated interest in developing a more comprehensive estimate of these emissions from the upstream oil and gas industry. To steer the development of a comprehensive criteria air contaminant emissions inventory for the upstream oil and gas industry, a subgroup was established within the Emissions and Projections Working Group. The subgroup, in cooperation with Environment Canada, directed the development of a technical manual detailing the methodology for development of a national inventory of criteria air contaminant emissions by the upstream oil and gas industry. The manual was prepared by Clearstone Engineering Ltd. and released in September 2003. In March 2004, a comprehensive draft inventory of criteria air contaminant emissions was prepared by Clearstone Engineering Ltd. for 1990–2000, in accordance with the methodology mentioned above, through the collaborative efforts of the Canadian Association of Petroleum Producers (with substantial input from producers through their Climate Change Technical Committee), Environment Canada, Natural Resources Canada, the provinces of Alberta and British Columbia, provincial and territorial resource management agencies and the Emissions and Projections Working Group subgroup.

The emissions inventory was developed using a bottom-up approach, beginning with individual process units and activities and the following primary types of emission sources: fugitive equipment leaks, reported and unreported venting, flaring, storage losses, loading losses, fuel combustion (e.g., by compressor engines, pumpjacks, process heaters and boilers, drilling rigs and electric power generators) and accidental releases. The determined emissions were then aggregated to determine emissions by facility and geographic area.

The applied emissions assessment methodology was determined on a case-by-case basis, with the objective being to obtain the most reliable estimate possible from the information available. The basic methods considered in each case are listed below in order of decreasing preference:

- *Emission monitoring results*: Some facilities, as a condition of their operating approval, are required to monitor and report their atmospheric emissions of certain substances (e.g., SO_2). The use of actual emission monitoring results is the preferred approach wherever such data are available.

- *Emission source simulation results*: Computer models are available for estimating emissions from some types of sources (e.g., GRI GlyCalc for predicting emissions from glycol dehydrators and U.S. EPA TANKS to predict evaporation losses from storage tanks). These models apply empirical correlations and/or fundamental engineering principles to develop rigorous emission estimates based on the specific operating and design parameters of the source. When properly applied, simulators offer the ability to accurately predict emissions from individual sources (generally to within ±25% or better), but have the disadvantages of requiring more time, effort, user knowledge and input data to apply. Moreover, the necessary design and operating input data may be difficult to obtain. Consequently, the use of emission source simulations herein is primarily limited to the development of emission factors based on typical process and operating conditions for different segments of the industry.

- *Emission factors*: This is a statistical approach in which the average emission from a group of sources is related to an appropriate activity value using a simple relation of the form:

$$ER_i = EF_i \cdot AR \cdot (1 - CF_i)$$

where:

ER_i = emission rate of substance *i* for the selected source;
EF_i = emission factor for estimating emissions of substance *i* from the selected source;
AR = activity rate for the parameter to which the emission factor applies (e.g., amount of fuel consumed); and
CF_i = efficiency of any emission control (or abatement) device that may be used on the emission source that is not accounted for in the applied emission factor. In the absence of specific data, it will be assumed that the target sources have no special controls.

The use of emission factors is often an oversimplification that may be subject to very high uncertainties (e.g., orders of magnitude) when applied to a single source, but becomes a statistically valid approach when considering aggregate emissions from large numbers of sources. The available sources of emission factors are, in order of decreasing preference, custom factors based on recent emission measurements of the target source, manufacturers' values, Canadian-specific values and published values from the open literature (e.g., U.S. EPA's AP-42 compilation of air pollutant emission factors).

- *Destruction and removal efficiencies*: The emissions of individual substances input to a combustion device may be estimated based on the extent to which they are expected to be destroyed (i.e., converted to intermediate, partially oxidized and fully oxidized products of combustion) and/or removed by that device. This is done using a relation of the form:

$$DRE_i = (1 - ER_i/IR_i) \cdot 100$$

where:

DRE_i = destruction and removal efficiency of substance *i* for the selected source;
ER_i = emission rate of substance *i* from the selected source; and
IR_i = input rate of substance *i* to the selected source.

2.12.4 Activity Level

Activity levels were calculated for the following primary emission source categories as follows:

- *Fuel combustion*: Comprises the combustion of fuel withdrawn from the process and fuel purchased from third parties. The amount of fuel withdrawn from the process was determined directly from available production accounting statistics. Data on actual fuel purchases were obtained for all major consumers of purchased fuel gas (e.g., full-scale thermal recovery projects), and estimates based on extrapolations of available survey results were prepared for all other facilities. No corrections were made to the fuel data to account for any fuel used for non-combustion purposes (e.g., purge gas, instrument gas, compressor start gas, blanket gas). At each site, total gas use was prorated to the actual or expected types of combustion sources (e.g., reciprocating engines, turbines, heaters and boilers and incinerators). Fuel used to adjust the heating value of waste gas streams to allow stable flaring was not directly evaluated; rather, this portion of total fuel consumption was allocated proportionately to the other combustion source categories at each site. Site-specific fuel gas analyses were applied where available; otherwise, appropriate default values were used.

- *Flaring*: A distinction was made between acid gas flaring and all other types of flaring. The gas compositions were determined using either available site-specific data or typical default values by industry sector. The amount of both types of flaring was taken directly from the available production accounting statistics. No corrections were made to try to account for any gas volumes reported as flared but actually vented. Additionally, no corrections were made to account for leakage into flare systems.

- *Reported venting*: Vented volumes, as stated in production accounting statistics. These volumes are assumed to comprise, where applicable, casing gas venting, waste-associated gas flows, treater and stabilizer off-gas and gas volumes discharged during

process upsets and equipment depressurization events. Storage and loading/unloading losses are assumed to be generally excluded from reported vented volumes and therefore are assessed separately.

- *Unreported venting*: The sum of all miscellaneous vented volumes not normally included in reported vented volumes and not otherwise accounted for in the developed emissions inventory. This may include instrument vent gas, compressor start gas, purge gas or blanket gas that is discharged directly to the atmosphere and dehydrator still column off-gas.

- *Fugitive equipment leaks*: The loss of hydrocarbon gas and liquids to the atmosphere past mechanical connections, seals and valve seats due to normal wear and inefficiencies in these mechanisms.

- *Storage losses*: Comprise normal evaporation losses due to breathing and working effects, plus flashing losses where the received liquids have an initial vapour pressure close to or greater than local atmospheric pressure. Gas carry-through to storage tanks due to leakage past drain valves into tank inlet headers, inefficient gas–liquid separation in upstream vessels, malfunctioning level controllers or leakage past the seat of level control valves or unintentional storage of high vapour pressure liquids in atmospheric tanks are known to be noteworthy sources at some sites but could not be accounted for due to a lack of appropriate emission factors.

2.12.5 Comparison of 2006 Methods with Previous Methodology

The 2006 inventory was complied with a different process from that of the previous inventory. Prior inventories used a bottom-up approach to estimate the emissions for this sector; in 2006 a combination of facility reported data and top-down methods were utilized to create the comprehensive inventory for Area Sources (AS).

The AS data was estimated using a top-down approach and included the following categories of the inventory for this sector:
- Crude Oil and Natural Gas Production and Processing
- Other Upstream Petroleum Industry

The top-down approached was based on the comprehensive AS source data from 2005 to which growth factors were applied. The growth factors were determined from the 2005 and 2006 NPRI data; effectively a ratio of 2006 to 2005 data. NOTE: Because of the reporting thresholds for the Criteria Air Contaminant (CAC) substances the NPRI data could not directly be used to represent the two AS categories (more specifically, not all facilities represented in the two AS categories are reportable under the NPRI.) Once the 2006 estimates were created with the use of the growth factors, checks were conducted to ensure the data was consistent and robust.

2.12.6 Alternative Methods Used by Provinces/Territories

There were no alternative methods used by the provinces.

2.12.7 References

Canadian Association of Petroleum Producers. 2005a. A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H$_2$S) Emissions by the Upstream Oil and Gas Industry. Volume 2. Overview of the CAC and H$_2$S Inventory. Final Report. Prepared by Clearstone Engineering Ltd. January.

Canadian Association of Petroleum Producers. 2005b. A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H$_2$S) Emissions by the Upstream Oil and Gas Industry. Volume 4. Methodology for CAC and H$_2$S Emissions. Final Report. Prepared by Clearstone Engineering Ltd. January.

Canadian Gas Association. 2004. Canadian Natural Gas Companies 2000 Greenhouse Gas Inventory Report and Validation by Audit. Prepared by ICF Consulting Ltd.

2.12.8 Guidebook Sector Documentation Record

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Date: April 2009

Author: Jason Hawirko, Pollution Data Division / Canadian ORTECH
Environmental

INDUSTRIAL SECTOR

2.13 WOOD INDUSTRIES

2.13.1 General Description

This sector includes sawmill, plywood and veneer and boards production. In 2003 lumber from sawmills accounted for about 69% of the volume of wood handled, followed by 19% for plywood and veneer production and the remainder for boards production.

British Columbia accounted for 46% of sawmill production, with Quebec accounting for 25%, Ontario for 11% and the remaining 19% distributed among the other provinces and territories. British Columbia produced 80% , Quebec and Ontario produced each 9% of plywood and veneer, respectively. Quebec, Ontario, Alberta and British Columbia were all major board producers.

2.13.2 Sector Description

Sawmill Production

Sawmill production involves the debarking and sawing of logs into lumber, with associated surface finishing operations. Process emissions of particulate matter and VOC are estimated for this source. Emissions of particulate matter, SO_x, NO_x, VOCs and CO related to the combustion of wood and wood waste in boilers associated with the sawmill operations are inventoried separately. Any emissions associated with other fuel combustion are inventoried with industrial fuelwood combustion or wood waste incineration sources.

There are a number of processes potentially involved in a sawmill operation: log debarking, log sawing (fugitive), sawdust pile handling, sawing, planing/trimming and sanding.

Plywood and Veneer Production

Plywood is composed of thin layers of wood (veneers) bonded together with an adhesive. The outer layers (faces) surround a core that is usually lumber, veneer or particleboard. Most plywood is made from Douglas fir or other softwood (Environment Canada 1983; U.S. EPA 1985). Principal emissions from these operations are VOCs and particulate matter (Environment Canada 1983).

In the production of plywood, logs are sawed to the required length, debarked and peeled into veneers of uniform thickness. These veneers are then put into dryers to reduce their moisture content. After drying, veneers go into a layout operation, where they are sorted, patched and layered and a thermosetting resin adhesive is applied. The veneer assembly is then transferred to a hot press where the pressure and steam form the product. Final

processing involves trimming, face sanding and possibly use-specific finishing treatments (U.S. EPA 1985). VOC emissions occur primarily during the product drying stage, although some also occur while curing plywood in the pressing stage. These emissions originate primarily from evaporation of natural organic oils present in the wood and due to the operation of the dryer (particularly gas-fired) and, to a lesser extent, from the synthetic resins used. Therefore, the quantity and type of organics emitted vary depending on the wood species and on the dryer type and its method of operation. Controls are not usually installed to limit VOC emissions (Edwards and Cotton 1988). Particulate matter emissions arise from log sawing, debarking, veneer cutting and plywood cutting and sanding operations. The dust that escapes into the air from sanding, sawing and other woodworking operations may be controlled by collection in an exhaust system and transported through duct work to a sized cyclone. Particulate matter emissions from the veneer dryers are considered negligible.

Boards Production

Boards production includes wafer board, particleboard, fibreboard, rigid insulating board and shingles and shakes. Principal emissions from these operations are VOCs and particulate matter.

Emissions from the production of board products are similar to those in plywood and veneer production.

Only process emissions of particulate from all of these types of wood production are inventoried as area sources. VOC emissions (e.g., wood pressing and adhesive use) are inventoried as point sources. Emissions from fuel combustion are inventoried as industrial fuelwood sources and wood waste incineration sources (see sections 2.14 and 5.3 of this guidebook).

2.13.3 Inventory Method

Wood product industry emissions were calculated using particulate and VOC emission factors for sawmill, particulate emissions from plywood and veneer and boards production, as listed in Tables 2.13-1, 2.13-2 and 2.13-3. These emission factors are based on cubic metres of product. The emission factors are from a variety of sources, including U.S. EPA AP-42 (U.S. EPA 1985, 1995) and previous inventories. The assumed controls on particulate emissions are based on the information provided in the 1990, 1985 and 1980 criteria air contaminant inventories. The PM_{10} and $PM_{2.5}$ emission factors are based on total particulate emissions, using equations that were taken from the U.S. EPA's PM Calculator program, as follows:

$$PM_{10} \text{ EF} = 0.58 \cdot \text{TPM EF}$$
$$PM_{2.5} \text{ EF} = 0.19 \cdot \text{TPM EF}$$

Table 2.13-1: Sawmill Emission Factors

Source	Sawmills Emission factors (g/m3) [1]			VOC[2]
	TPM	PM_{10}	$PM_{2.5}$	
Sawmills uncontrolled	1476.20	856.20	280.48	300
Sawmills controlled[1]	1318.26	764.59	250.47	

Note:
1. U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.
(www.epa.gov/ttn/chief/ap42/index.html) Control assumed is 10.7%.

2.Innovative procedures to quantify Volatile Organic Compound emissions from Lumber Kilns, Glass and Elam, 1995 International Environmental Conference proceedings, p.215

Table 2.13-2: Plywood and Veneer Emission Factors

Source	Emission factors (g/m^3)		
	TPM	PM_{10}	$PM_{2.5}$
Uncontrolled	6268.70	3635.85	1191.05
Controlled[1]	2013.76	1167.98	382.61

Note:
Note:
1. U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.
(www.epa.gov/ttn/chief/ap42/index.html) Control assumed is 10.7%.

Table 2.13-3: Board Emission Factors

Source	Emission factors (g/m^3)		
	TPM	PM_{10}	$PM_{2.5}$
Uncontrolled	4995.00	2897.10	949.05
Controlled[1]	890.50	516.49	169.20

Note:
Note:
1. U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.
(www.epa.gov/ttn/chief/ap42/index.html) Control assumed is 10.7%.

2.13.4 Activity Level

The base quantities included in wood industries are divided into three separate standard classification codes: sawmill production, plywood and veneer production and boards production.

The CANSIM tables were used for the activity level for sawmill production.
The activity level calculations for wafer board, particleboard, and fibreboard were taken from CANSIM tables. 2000 provincial and territorial productions were used for the distribution of the Canadian production of lumber across the provinces.

For shingles and shakes and fibreboards (included in the boards category), and plywood, the activity level in m3 was prorated from 1995 levels.

Statistics Canada did not provide any information for the Yukon, the Northwest Territories or Nunavut for any of the sectors included in wood industries. Therefore, the activity level was considered 0 and no emissions have been estimated for any of these territories within the national inventory.

2.13.5 Comparison of 2006 Methods with Previous Methodology

At the recommendation of the Forest Products group the sawmill fugitive emissions for PM were removed due to old unverified EF, difference with the NPRI toolbox and others. HM, D/F and PAH emissions from Wood Waste Incineration were removed because they were deemed not significant emissions as per the NPRI Case Study, March 2007.

2.13.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces.

2.13.7 References

NPRI, "Case Study 1: Sawmill Operation", Final Version, April 2006

Edwards, W.C. and Cotton, T. 1988. VOC Emissions Methods Manual. Prepared by B.H. Levelton & Associates Ltd. for Environmental Analysis Branch, Environment Canada.

Statistics Canada CANSIM tables,
  v1176- from Table 303-0002 Waferboards
  v1175 from table 303-0002 for Particleboards
  v1178 from table 303-0002 for Fibreboards
  v1758 - from Table 303-00092,3: Sawn lumber production and shipments

U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/index.html)

 Innovative procedures to quantify Volatile Organic Compound emissions from Lumber Kilns, Glass and Elam, 1995 International Environmental Conference proceedings, p.215

2.13.8 Guidebook Sector Documentation Record

Release Version: 1

Date: April 2008

Author: Patrick Georges /Pollution Data Division

INDUSTRIAL SECTOR

This sector is included in WOOD INDUSTRIES and needs to be deleted

2.14   INDUSTRIAL FUELWOOD COMBUSTION

2.14.1 General Description

Hog fuel is made from forest industry wood residue (mostly bark) that has been ground down. It is combusted in high-pressure steam boilers in pulp mills, large sawmills, veneer and plywood mills and composite products plants.

Combustion of wood residue is highest in British Columbia, followed, in decreasing order, by Quebec, Ontario, Alberta and New Brunswick. No industrial wood combustion was reported for Prince Edward Island or the territories.

2.14.2 Sector Description

Stationary external combustion sources are primarily used in industry for the generation of process steam and space heating. Wood is the fuel included in this sector. In the pulp and paper sector, wood fuel often includes bark and wood waste, commonly called hog fuel.

The emissions from these units will reflect the age and technology of the boiler, boiler emission control equipment and the fuels fired. Particulate matter in older units is controlled with mechanical collectors (multi-cyclones); since the mid-1980s, however, particulate matter has been controlled with electrostatic precipitators. These emissions are also affected by operating practices, such as limiting changes in the firing rate of wood fuel and maintaining good combustion conditions in the furnace.

Emissions of particulate matter, SO_2, NO_x, CO and VOCs are inventoried for this sector. Heavy Metals, Dioxins and Furans, and PAHs are also inventoried.

2.14.3 Inventory Method

Emission factors (Table 2.14-1) based on the annual industrial combustion of solid wood waste in tonnes was used to estimate area source emissions from this subsector. These emission factors are the average of uncontrolled emission factors for the combustion of wood waste in spreader stoker boilers, fuel cells (dutch oven boilers) and fluidized bed boilers, as reported by H.A. Simons Ltd. (1995). A conversion factor of 18 GJ/t of wood waste (Statistics Canada Catalogue No. 57-003-XIB) was used to express these emission factors in kg/kt of waste burned. The PM_{10} and $PM_{2.5}$ emission factors were calculated using the following equations taken from the U.S. EPA's PM Calculator program:

$$PM_{10}\ EF = 0.9 \cdot TPM\ EF$$
$$PM_{2.5}\ EF = 0.76 \cdot TPM\ EF$$

Table 2.14-1: Emission Factors for the Combustion of Wood in Industrial Boilers

Source	Emission factors (kg/kt)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3
Industrial fuelwood combustion	9045.00	8140.50	6874.20	15.30	1134.00	234.00	6143.94	126.00

Source: H.A. Simons Ltd. (1995)

Table 2.14-2: Heavy Metal Emission Factors

Emission factors (kg/Tonne)		
Hg	Cd	Pb
3.25*10 e-06	8.50*10e-06	2.23*10e-04

Source: Fire 6.25

Table 2.14-3: Dioxin and Furan Emission Factors

Emission factors (ng I-TEQ/kg wood)
0.56

Sources :   Emission factors for dioxins and furans are from the Draft Dioxin Reassessment (2003)

Table 2.15-4: Poly Aromatic Hydrocarbon Emission Factors

Emission factors (kg/Tonne)			
B(a)p	B(b)f	B(k)f	I(cd)p
9.5*10e-08	1*10e-04	3.6*10e-5	1.7*10e-7

Sources:
PAH: B(a)p Fire 6.25, SCC 10100903, woodfired boiler wet wood uncontrolled
PAH: B(b) f, Fire 6.25, SCC 10100903, wood fired boiler wet wood uncontrolled
PAH: B(k) f, wood fired boiler wet wood uncontrolled.
PAH: I(cd) P: FIRE 6.25, SCC 101000903, Wood/bark waste, wood fired boiler, wet wood uncontrolled.

2.14.4 Activity Level

The base quantities of wood consumed as industrial fuelwood were taken from Statistics Canada Catalogue No. 57-003-XIB. This lists quantities of wood waste by province. Newfoundland and Labrador and Nova Scotia were combined. It was assumed that 75% of the wood waste was produced in Newfoundland and Labrador and 25% was produced in Nova Scotia, consistent with the 1995 inventory assumptions.

Wood waste is generally defined as wood that cannot be used to manufacture primary products — generally wood chips, bark and bolts. It is assumed that 85% of this waste is solid wood waste used as fuel in industrial boilers.

In 2005, growth factors were used to prorate the 2004 activity levels (2005-2004 Growth Factors Canada.xls).

2.14.5 Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 1995 inventory for this sector. In 2005, the activity levels from 2004 were prorated to obtain the 2006 data. The Estimation for 2006 is still in progress.

2.14.6 Alternative Methods Used by Provinces/Territories

No alternative area source methodologies were used by the provinces.

2.14.7 References

H.A. Simons Ltd. 1995. Emissions and Control Options for Wood and Wood Derived Fuel Fired Industrial Combustion Systems. P.5517B. April.

Statistics Canada. Annual. Report on Energy Supply-Demand in Canada. Catalogue No. 57-003-XIB.

U.S. EPA. 2004. Factor Information REtrieval (FIRE) v6.25, October 2004. http://www.epa.gov/ttn/chief/software/fire/index.html

US Environmental Protection Agency (EPA).   2003.   Draft Dioxin Reassessment. (http://cfpub.epa.gov/ncea/cfm/part1and2.cfm?ActType=default)

2.14.8 Guidebook Sector Documentation Record

Release Version: 1

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Author: Patrick Georges Pollution Data Division
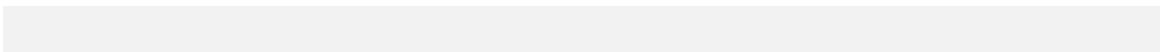
INDUSTRIAL SECTOR

2.15   INDUSTRIAL FUEL COMBUSTION

2.15.1 General Description

In 2003, the total demand for coal by industrial fuel combustion in Canada was 1590 kilotonnes. Ontario consumed the most coal at 31%, followed by Quebec with 30%. Almost36% of coal was consumed by the cement industry in Canada.

Sixty- five percent of the heavy fuel oil consumed for industrial fuel combustion is by the pulp and paper sector in New Brunswick, Quebec, Ontario and British Columbia. Over 70% of the kerosene and stove oil consumed in Canada for industrial fuel combustion is by the mining industry. Light fuel oil is primarily consumed by other manufacturing industries (approx. 43%) followed by the mining (approx.21%) and construction sectors (approx. 21%). (Statistics Canada, 2003).

Natural Gas is consumed for industrial fuel combustion by nearly every sector in Canada with other manufacturing (approx 37%) being the largest. The mining, pulp and paper, petroleum refining and chemical sectors also account for approx. 48% combined. Activity is primarily concentrated in Central Canada (Ontario and Quebec) with Alberta and British Columbia being the next two largest contributors.

Nearly three-quarters of the natural gas liquids used for industrial fuel combustion are consumed by the mining sector, largely in Ontario, but with distribution through nearly all provinces and territories.

2.15.2 Sector Description

Stationary external combustion sources are primarily used in industry for the generation of process steam and space heating. Some units are also used for electricity generation. Fuels included in this sector include natural gas, natural gas liquids, kerosene and stove oil, coal, coke, residual oil and distillate oil.

Internal combustion units used in industry are inventoried as point sources in this sector or as area sources under off-road use of diesel or gasoline.

Emissions of particulate matter, SO_2 and NO_x are inventoried for this sector. Coal and distillate oil-fired industrial combustors are significant sources of SO_2, NO_x and TPM. Natural gas-fired combustors also emit significant amounts of NO_x.

Bituminous dry-pulverized and spreader stoker coal-fired units are the most common large-sized coal-fired units, whereas smaller needs are more commonly met with underfeed and overfeed stokers. Lignite and anthracite coal are usually burned in stokers. Oil- and natural gas-burning units are usually watertube or firetube boilers.

Emissions control on industrial boilers is mainly directed at reducing particulate flue gas emissions from coal-fired boilers. This is achieved using baghouses, electrostatic precipitators, wet scrubbers and multi-cyclones. Flue gas desulfurization units for SO_2 control are much less common in industrial coal-fired units than in the utility sector, but are used. SO_2 control is more commonly achieved through the use of low-sulfur coal.

Particulate emissions from oil-fired industrial combustors are usually not controlled. Any units with potentially excessive SO_2 emissions usually switch to low-sulfur oils rather than install emission controls. Natural gas units also do not usually have any sort of emissions control.

2.15.3 Inventory Method

Emission factors (Table 2.15-1) based on annual fuel combustion (natural gas, natural gas liquids, kerosene and stove oil, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal and imported bituminous coal) on a volume or weight basis were used to estimate area source emissions from this subsector. For TPM, PM10, PM2.5, SOx, NOx, VOCs and CO, uncontrolled emission factors were taken from the 5th edition of AP-42 (U.S. EPA 1995) and were chosen to represent the typical type of combustion equipment for each fuel type. For SO_x emission factors, except for natural gas and natural gas liquids, the factors given in Table 2.15-1 must be multiplied by the sulfur content in percent, as summarized in Table 2.15-2. The SO_x emission factors for natural gas assume a density of 0.58 kg/m^3 and an average sulfur content of 4600 g/10^6 m^3. The emission factors for the natural gas liquids assume a density of 0.42 kg/m^3 and a sulfur content of 4600 g/10^6 m^3. As indicated in Table 2.15-1, Quebec chose to use a different emission factor for natural gas combustion. There were changes in the sulfur content in kerosene/stove oil, light fuel oil and heavy fuel oil for all provinces.

The uncontrolled NH3 emission factors found in Table 2.15-1 were selected from a number of different sources. For combustion of natural gas, natural gas liquids, light fuel oil and heavy fuel oil, emission rates were taken from "Review of Current Methodologies for Estimating Ammonia Emissions" (Coe et al. 1996). For combustion of Canadian bituminous, lignite, anthracite and imported bituminous coals, a general emission factor for coal was used.   This value was selected from the EPA document entitled "Development and Selection of Ammonia Emission Factors" and was assumed to be applicable to all three categories (Battye et al. 1994). Finally, the emission factors for kerosene and sub-bituminous coal were derived from emission rates provided in the document "Atmospheric Emission Inventory Guidebook" (EMEP 1996). Because this document provided a range for the emission rates of sub-bituminous coal, the average was calculated. In addition, conversion factors of 18.3 TJ/kt for sub-bituminous coal and 37.68 TJ/Ml of kerosene (Statistics Canada 1996) were used to express the emission factors in units of kg per tonne of coal burned and kg per kl of kerosene burned, respectively.

Table 2.15-1: Emission Factors for Industrial Fuel Combustion (CAC and NH3)

Fuel	Emission factors (units as specified)							
	TPM	PM$_{10}$	PM$_{2.5}$	SO$_x$[1]	NO$_x$	VOCs	CO	NH$_3$
Natural gas (kg/10^6 m^3)	216.1500	216.1500	216.1500	9.6000	3224.0	41.0220	572.0000	52.8550[2]
Natural gas (kg/10^{6}m^3), Quebec[3]	192.000	192.000	192.000	9.600	1600.0	84.4800	330.000	52.8550
Natural gas liquids (kg/kl)	0.0700	0.0700	0.0700	0.0115	2.4000	0.0650	0.4000	0.0359
Kerosene and stove oil (kg/kl)	0.2400	0.1200	0.0300	17S	2.4000	0.0240	0.6000	0.0075
Light fuel oil (kg/kl)	0.2400	0.1200	0.0300	17S	2.4000	0.0240	0.6000	0.1198
Heavy fuel oil (kg/kl)	1.12S^2+0.37	0.86*TPM	0.56*TPM	19S	6.6000	0.0340	0.6000	0.1102
Coal Canadian bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003
Coal sub-bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0057
Coal lignite (kg/t)	4.0000	0.8000	0.2800	15S	2.9000	0.1000	0.3000	0.0003
Coal anthracite (kg/t)	0.4400	0.23*TPM	0.06*TPM	19.5S	1.5000	0.1000	0.3000	0.0003
Coal imported bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003

Notes:
1. The SO$_x$ emission factors must be multiplied by the sulfur content in percent, except for natural gas and natural gas liquids. S means sulfur content in mass percent.
2. The NH$_3$ emission factor used for the petroleum industry differed from the other industrial sectors. For the petroleum industry only, a value of 43.2450 kg per 10^6 m^3 of natural gas combusted was applied (Coe et al. 1996)
3. Quebec chose to use a different emission factor for natural gas combustion in the other manufacturing sector.

Table 2.15-2: Heavy Metal Emission Factors

Fuel	Emission factors (units as specified)		
	Hg	Cd	Pb
Natural gas (kg/GL m^3)	4.165E-03[1]	1.762E-02[1]	8.009E-03[1]
Heavy fuel oil (kg/kl)	1.356E-05[1]	4.776E-05[1]	1.812E-04[1]
Coal Canadian bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal sub-bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal lignite (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal imported bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]

Notes:
1 AP-42 Chapter 1
2 CARB CATEF database
3 FIRE 6.25 database

Table 2.15-3: Dioxin and Furan Emission Factors

Fuel	Emission factors (units as specified)
Light fuel oil (ng/L)	0.2
Heavy fuel oil (ng/L)	0.2
Coal Canadian bituminous (ng/kg)	0.6
Coal sub-bituminous (ng/kg)	0.6
Coal lignite (ng/kg)	0.6
Coal anthracite (ng/kg)	0.6
Coal imported bituminous (ng/kg)	0.6

Notes:

Emission factors for dioxins and furans are from the Draft Dioxin Reassessment (2003)

Table 2.15-4: Poly Aromatic Hydrocarbon Emission Factors

Fuel	Emission factors (units as specified)			
	B(a)p	B(b)f	B(k)f	I(cd)p
Natural gas (kg/Gm^3)	1.92E-05[2]	2.88E-05[2]	2.88E-05[2]	2.88E-05[2]
Kerosene and stove oil (kg/kl)	1.61E-07[2]	1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Light fuel oil (kg/kl)	1.61E-07[2]	1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Heavy fuel oil (kg/kl)	1.294E-07[3]	3.511E-06[3]	3.391E-06[3]	2.568E-07[2]
Coal Canadian bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal sub-bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal lignite (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal anthracite (kg/t)	2.65E-06[2]	1.25E-05[2]	1.25E-05[2]	3.45E-06[2]
Coal imported bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]

Notes:

1. AP-42 Chapter 1
2. FIRE 6.25 database
3. CARB CATEF database

Table 2.15-5: Sulfur Content in Fuel for Area Source Industrial Fuel Combustion for 2003

Fuel	Sulfur content in fuel (%)[1]												
	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT	NU
Kerosene and stove oil	0.03 (0.052)	0.03 (0.052)	0.03 (0.052)	0.03 (0.052)	0.046 (0.045)	0.040 (0.044)	0.026 (0.034)	0.026 (0.034)	0.026 (0.034)	0.026 (0.034)	0.026 (0.034)	0.026 (0.034)	0.026 (0.034)
Light fuel oil	0.110 (0.127)	0.110 (0.127)	0.110 (0.127)	0.110 (0.127)	0.187 (0.198)	0.151 (0.216)	0.04 (0.07)	0.04 (0.07)	0.04 (0.07)	0.04 (0.07)	0.04 (0.07)	0.04 (0.07)	0.04 (0.07)
Heavy fuel oil	1.864 (1.915)	1.864 (1.915)	1.864 (1.915)	1.864 (1.915)	1.136 (1.128)	1.428 (1.495)	1.571 (1.439)	1.571 (1.439)	1.571 (1.439)	1.571 (1.439)	1.571 (1.439)	1.571 (1.439)	1.571 (1.439)
Coal Canadian bituminous	7	7	7	7	1.6	1.55	0.3	0.3	0.02 (0.024)	0.02 (0.024)	0.02 (0.024)	0.02 (0.024)	0.02 (0.024)
Coal sub-bituminous	159 (2.0)	159 (2.0)	159 (2.0)	159 (2.0)	159 (2.0)	0.2	0.35	0.45	0.2	0.29	0.2	0.2	0.2
Coal lignite	0.4	0.4	0.4	0.4	0.4	0.6	0.4	0.562	0.6	0.6	0.6	0.6	0.6
Coal anthracite	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Coal imported bituminous	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Ref: HFO, LFO, Kerosene and Stove Oil: "Sulphur in Liquid Fuels 2005", Environment Canada
Coal: CEA "Sulphur Content in Liquid Fuels", a national average of coal used in power plants was used.
Canadian Electricity Association Mercury Program, 2005

2.15.4 Activity Level

Base quantities of fuel combusted in industrial boilers by province/territory for 2006 was taken from Statistics Canada Catalogue No. 57-003-XIB and the statistics Canada database 2005/2006.

Table 2.15-6: Statistics Canada Sector Definitions[1]

Sectors	Definition
Iron mines	Includes iron mines only. SIC80: 0617.
Total mining (sum section)	Includes metal mines, non-metal mines, coal mines, crude petroleum and natural gas industries, stone quarries, gravel pits and contract drilling operations. SIC80: 061, 062, 063, 071, 081, 0911 and 0921.
Pulp and paper and sawmills	Includes establishments in the sawmill and pulp and paper industries. SIC80: 2512 and 271.
Iron and steel	Establishments operating blast furnaces, casting mills, rolling mills or coke ovens operated in association with blast furnaces. SIC80: 291.
Smelting and refining	Establishments engaged in the primary production of aluminum and in the refining of non-ferrous metals. SIC80: 295.
Cement	Establishments engaged in the manufacturing of (hydraulic) cement. SIC80: 352. This classification does not include concrete or ready-mixed concrete operations.
Petroleum refining	Establishments engaged in manufacturing refined petroleum products including fuels and blended oils and greases. SIC80: 361.
Chemicals	Establishments engaged in manufacturing industrial organic and inorganic chemicals and chemical fertilizers. SIC80: 371 and 3721.
Other manufacturing	All other manufacturing industries not listed above. SIC80: 101 to 399 less 2512, 271, 295, 352, 361, 371 and 3721. In some instances, this classification is used when no breakdown of the component manufacturing industries is provided
Total manufacturing (undetermined value)	Total manufacturing value less known value gives unknown value (too small, hidden or confidential). SIC80: variable.
Total manufacturing (sum section)	The summation of manufacturing industries pulp and paper to other manufacturing.
Forestry	Includes establishments in the forestry sectors. SIC80: 04 and 05.
Construction	SIC80: 401 to 429.
Total industrial (sum section)	The total of the usage in the mining, manufacturing, forestry and construction sectors.

Note:
1. See Definitions section of Catalogue No. 57-003-XIB.

2.15.5 Comparison of 2006 Methods with Previous Methodology

The emission factors for the CAC and NH3 are the same for 2003 as for previous years; however other pollutants were added in 2003.   Due to confidentiality, coal use by coal type by industry sector was not available from Statistics Canada in previous years but where available for 2006 in the database. Values for coal use in mining, cement, total manufacture, and total industrial were available for some provinces in 2003. Thus, distributions for 2003 were assigned using 2000 proportions with considerations for available 2003 data.

For 2003, the ammonia emission factor for lignite coal combustion was changed from 0.00653 kg/t to 0.0003 kg/t in order to be consistent with the US EPA's FIRE v6.25 database (US EPA 2004).

Sulfur contents where updated according to Canadian Electric Associations 2005 Mercury Program.

2.15.6 Alternative Methods Used by Provinces/Territories

As indicated in Table 2.15-1, Quebec chose to use a different emission factor for natural gas combustion in the other manufacturing sector. Otherwise, no alternative methodologies were used by the provinces/territories for this sector.

2.15.7 References

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2.15.8 Guidebook Sector Documentation Record

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CHAPTER 3
NON-INDUSTRIAL FUEL COMBUSTION SECTOR

3.1 Commercial Fuel Combustion
3.2 Electric Power Generation
3.3 Residential Fuel
3.4 Residential Fuelwood

NON-INDUSTRIAL FUEL COMBUSTION SECTOR

3.1   COMMERCIAL FUEL COMBUSTION 2006

3.1.1   General Description

In 2006, commercial and institutional natural gas consumption was highest in Ontario, with no consumption in the eastern provinces. Natural gas liquids are primarily used in Ontario, Quebec and Alberta. Moreover, light fuel oil use is highest in Ontario and Quebec. The use of kerosene is minor and distributed across the country while the highest consumption of heavy fuel oil occurs in Quebec. Public administration consumption was at lower levels than commercial and institutional fuel consumption.

3.1.2   Sector Description

This category includes only external combustion sources used for space/water heating in commercial establishments, health and educational institutions and government/public administration facilities. Internal combustion sources used by this sector (primarily oil-fired reciprocating engines used for pumping water and sewage) are included in off-road use of diesel. Particulate matter, SO_2, CO, NO_x and VOCs are all emitted from commercial/institutional fuel combustors.

Commercial/institutional external combustion sources may be classified by the boiler/furnace design or type of fuel. Further characterizations include installed capacity and firing method. Smaller units (<13.2 J/h) are typically cast iron or firetube units. Watertube units constitute 100% of all units above 50×10^9 J/h (Suprenant et al. 1981).

Possible fuel types include coal, distillate oil, residual oil, kerosene and stove oil, liquid petroleum gases and natural gas. Natural gas and petroleum products represented almost 100% of the energy consumption in this sector for Canada (MEP Company and Ontario Research Foundation 1985).

Air pollution control equipment is usually not installed on commercial/institutional combustion units. Some of the larger units, particularly the coal-fired boilers (pulverized or stoker), do have controls. These have automated particulate control efficiencies of 40% for pulverized units (primarily dry bottom) and 20% for all stokers, based on data in the U.S. National Emissions Data System. Gas- and oil-fired units are usually uncontrolled, although proper equipment selection, maintenance and operating practices can be used to limit emissions (Suprenant et al. 1981).

3.1.3 Inventory Method

Emissions from fuel combustion in the commercial sector are estimated using emission factors by fuel type and fuel burning process. The fuels considered for estimation are natural gas, gas plant natural gas liquids, kerosene and stove oil, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal and imported coals.

Uncontrolled CAC emission factors come from two US EPA sources. Natural Gas emission factors have been taken from the FIRE 6.25 emission factor database (2004), while all other CAC emission factors have been taken from Chapter 1 of the 5th edition AP-42 (1998). Emission factors were chosen to represent the typical type of combustion equipment for each fuel type.

Ammonia emission factors are from two separate sources by Battye et al (1994) and Coe et al (1996). CAC and ammonia emission factors are then summarized in Table 3.1-1.

Table 3.1-1: CAC & NH3 Emission Factors for Commercial Fuel Combustion

Fuel	Emission factors (units as specified)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO	NH_3
Natural gas (kg/GL)	161.9467	161.9467	161.9467	9.6000	1600.00	88.00	1344.00	8.3287
Natural gas liquids (kg/kl)	0.0550	0.0550	0.0550	0.0115	1.7500	0.0650	0.2500	0.0060
Kerosene and stove oil (kg/kl)	0.2400	0.1300	0.1000	17S[1]	2.4000	0.0410	0.6000	0.0960
Light fuel oil (kg/kl)	0.2400	0.1300	0.1000	17S	2.4000	0.0410	0.6000	0.1198
Heavy fuel oil (kg/kl)	1.12S + 0.37	0.62TPM	0.23TPM	19S	6.6000	0.1360	0.6000	0.1102
Coal Canadian bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003
Coal sub-bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003
Coal lignite (kg/t)	4A[2]	0.8A	0.28A	15S	2.9000	0.1000	0.3000	0.0003
Coal anthracite (kg/t)	0.44A	0.23TPM*A	0.06TPM*A	19.5S	4.6000	0.1000	0.3000	0.0003
Coal imported bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003

Notes:
1. S means sulfur content in mass percent.
2. A is the ash content of the fuel. It is assumed to be 1%, or 1.

Several emission factors are based on the weight percent of sulphur in the fuels. These are shown in Table 3.1-1 as the letter S. The sulphur contents of the fuels can change depending on the location of use. Sulphur contents of liquid fuels are given by the Oil

Gas & Energy Division of Environment Canada (2005). Coal sulphur contents are derived from information given by the CEA Mercury Program (2005). Table 3.1-2 shows the sulphur content of each fuel in their respective province or territory.

Table 3.1-2: Sulfur Content in Fuel for Commercial Fuel Combustion

Fuel	Sulfur content in fuel (%)												
	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT	NU
Kerosene and stove oil	0.06	0.06	0.06	0.06	0.04	0.31	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Light fuel oil	0.13	0.13	0.13	0.13	0.23	0.16	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Heavy fuel oil	1.97	1.97	1.97	1.97	1.07	1.76	1.56	1.56	1.56	1.56	1.56	1.56	1.56
Coal Canadian bituminous	7.00	7.00	7.00	7.00	1.6	1.55	0.3	0.3	0.02	0.0.2	0.0.2	0.0.2	0.0.2
Coal sub-bituminous	2.37	2.37	2.37	2.37	0.2	0.38	0.45	0.2	0.27	0.2	0.2	0.2	0.2
Coal lignite	0.40	0.40	0.40	0.40	0.4	0.6	0.4	0.56	0.60	0.6	0.6	0.6	0.6
Coal anthracite	1.60	1.60	1.60	1.60	1.6	2.49	1.6	1.6	1.60	1.6	1.6	1.6	1.6
Coal imported bituminous	1.5	1.5	1.5	1.5	1.5	0.94	1.5	1.5	1.50	1.5	1.5	1.5	1.5

Uncontrolled toxic emission factors are from 4 major sources: Chapter 1 of U.S EPA's AP-42, 5th edition (1998), U.S. EPA's FIRE 6.25 emission factor database (2004), California Air Resources Board's (CARB) Air Toxic Emission Factor (CATEF) database, and a document titled Draft Dioxin Reassessment (US EPA, 2003). Emission factors were chosen to represent the typical type of combustion equipment for each fuel type. Tables 3.1-3 to 3.1-5 summarize the toxic emission factors chosen for each fuel.

Table 3.1-3: Heavy Metal Emission Factors for Commercial Fuel Combustion

Fuel	Emission factors (units as specified)		
	Hg	Cd	Pb
Natural gas (kg/GL)	4.165E-03[1]	1.762E-02[1]	8.009E-03[1]
Natural gas liquids (kg/GL)	0[2]	1.430E-01[2]	1.146[2]
Kerosene and stove oil (kg/kl)	3.247E-07[2]	3.894E-05[2]	7.285E-05[2]
Light fuel oil (kg/kl)	3.247E-07[2]	3.894E-05[2]	7.285E-05[2]
Heavy fuel oil (kg/kl)	1.356E-05[1]	4.776E-05[1]	1.812E-04[1]
Coal Canadian bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal sub-bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal lignite (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal anthracite (kg/t)	6.500E-05[3]	3.550E-05[3]	4.450E-03[3]
Coal imported bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]

Notes:
1. AP-42 Chapter 1
2. CARB CATEF database
3. FIRE 6.25 database

Table 3.1-4: Dioxin and Furan Emission Factors for Commercial Fuel Combustion

Fuel	Emission factors (units as specified)
	I-TEQ Dioxin & Furan
Natural gas	0
Natural gas liquids	0
Kerosene and stove oil (ng I-TEQ/L oil)	0.15
Light fuel oil (ng I-TEQ/L oil)	0.15
Heavy fuel oil (ng I-TEQ/L oil)	0.15
Coal Canadian bituminous (ng I-TEQ/kg coal)	7.5
Coal sub-bituminous (ng I-TEQ/kg coal)	7.5
Coal lignite (ng I-TEQ/kg coal)	7.5
Coal anthracite (ng I-TEQ/kg coal)	2.1
Coal imported bituminous (ng I-TEQ/kg coal)	7.5

Notes:

Emission factors for dioxins and furans are from the Draft Dioxin Reassessment (2003)

Table 3.1-5: Poly Aromatic Hydrocarbon Emission Factors for Commercial Fuel Combustion

Fuel	Emission factors (units as specified)			
	B(a)p	B(b)f	B(k)f	I(cd)p
Natural gas (kg/GL)	1.92E-05[2]	2.88E-05[2]	2.88E-05[2]	2.88E-05[2]
Natural gas liquids (kg/kl)	0	0	0	0
Kerosene and stove oil (kg/kl)	1.61E-07[2]	1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Light fuel oil (kg/kl)	1.61E-07[2]	1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Heavy fuel oil (kg/kl)		1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Coal Canadian bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal sub-bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal lignite (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal anthracite (kg/t)	2.65E-06[2]	1.25E-05[2]	1.25E-05[2]	3.45E-06[2]
Coal imported bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]

Notes:

1. AP-42 Chapter 1
2. FIRE 6.25 database

3.1.4 Activity Level

Base quantities of fuel combusted in commercial/institutional boilers by province/territory for 2006 were taken from Statistics Canada Catalogue No. 57-003-XIB for the sectors listed in Table 3.1-6.

Table 3.1-6: Statistics Canada Sector Definitions[1]

Sectors	Definition
Public administration	All federal, provincial/territorial and local governments primarily associated with public administration. Includes the public service, Royal Canadian Mounted Police, National Defence and the Coast Guard.
Commercial and other institutional	This includes service industries related to mining, transportation, storage and warehousing, communications and utility (excluding electricity and natural gas), wholesale and retail trade, finance and insurance, real estate and business service, education, health and social services and other service industries. SIC divisions I, J, K, L, M, O, P, Q and R, as well as 0919, 0929, 4513, 4529, 4532, 455, 471, 481, 484, 493 and 499.

Note:
1. See Definitions section of Catalogue No. 57-003-XIB.

3.1.5 Comparison of 2006 Methods with Previous Methodology

Sulphur contents were updated.

3.1.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used for the 2006 inventory

3.1.7 References

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3.1.8   Guidebook Sector Documentation Record

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NON-INDUSTRIAL FUEL COMBUSTION SECTOR

3.2   ELECTRIC POWER GENERATION 2006

3.2.1   General Description

Natural gas use for power generation by utilities is largely practised in Ontario, Saskatchewan, and Alberta. Conversely, heavy fuel oil is largely used by utilities in eastern provinces and Quebec for power generation. Sub-bituminous coal is largely consumed in Alberta, whereas bituminous coal is mainly used in New Brunswick, Nova Scotia and Ontario. Saskatchewan also uses lignite coal in large quantities as well as Ontario. Of all these fuels, only natural gas is used by industry for power generation in amounts that constitute a significant portion relative to total utility consumption.

3.2.2   Sector Description

Electric power generation includes electrical power produced by utilities and by industry for commercial sale and/or private use. There are 10 fuel types considered: natural gas, coke oven gases, diesel fuel oil, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal and imported coal.

Particulate matter, SO_2, NO_x and CO are all emitted in significant quantities by this sector. VOCs, although emitted in much smaller quantities, are also inventoried.

The thermal power generation sector includes a wide variety of sources, including external and internal combustors that may be inventoried as point or area sources. Brief descriptions of external and internal combustors are provided below.

External Combustion

In pulverized coal furnaces, pulverized coal with the consistency of talcum power is generally entrained in primary air before being fed through the burners to the combustion chamber, where it is fired in suspension. Pulverized coal furnaces may be classified as either wet bottom or dry bottom, depending on the ash removal technique. Further classifications are based on the firing position of the burners (single front or rear wall, horizontally opposed, vertical, tangential, turbo or arch fired) (U.S. EPA 1985).

In cyclone furnaces, crushed low-ash fusion temperature coal is fed tangentially to a horizontal cylindrical combustion chamber. The finer coal particles burn while in suspension. The coarser particles are thrown to the walls by centrifugal forces. The walls have a surface coating of molten slag, which retains most of these coal particles until they are burned (Shih et al. 1980; U.S. EPA 1985).

Mechanical stokers burn coal in fuel beds (as opposed to burning in suspension). All mechanical stokers feed coal onto a grate with provisions for ash removal. The spreader stoker, most common in utility applications, introduces coal into the furnace over the fire bed with a uniform spreading action. Combustion occurs partly in suspension and partly on the grate. Fly ash reinjection from mechanical collectors is commonly employed to improve boiler efficiency. Anthracite coal is burned in travelling grate stokers because of the high ignition temperature. In these, coal is fed onto a travelling or vibrating grate and burns as it travels through the furnace (Shih et al. 1980; U.S. EPA 1985).

Coal handling operations such as loading and transfer result in the emission of particulate matter.

Residual oil utility boilers have burner arrangements similar to those for pulverized coal-fired utility boilers. Tangential, front wall and horizontally opposed are the primary firing configurations. Distillate oil and natural gas are primarily used for start-up and flame stabilization in boilers, and distillate oil is blended with residual oil to reduce the total sulfur content of the fuel oil consumed (Shih et al. 1979).

Three main types of emissions control are used for utility boiler emissions reduction: boiler modification, fuel substitution and flue gas cleaning. Boiler modification includes any physical change in the unit or its operation. Fuel substitution involves the firing of "cleaner" fuels by either substitution or blending. Flue gas cleaning on utility boilers is mainly directed at reducing emissions of particulates and SO_2.

For particulate control, electrostatic precipitators are the most common control for pulverized and cyclone furnaces, whereas multiple cyclones are generally used for stokers and oil-fired units. Natural gas-fired units do not normally have particulate control. Other particulate control devices include fabric filters (baghouses) and scrubbers (Shih et al. 1980; U.S. EPA 1985).

Flue gas desulfurization processes can be wet, semi-dry or dry. Wet systems, the most commonly applied system, generally use alkali slurries as the adsorbent medium. Particulate reduction of up to 99% is also possible with wet scrubbers, but flash is often collected by upstream electrostatic precipitators or baghouses to increase the efficiency and life span of these units. Flue gas desulfurization units are largely used on bituminous and lignite coal-fired units, although some oil-fired units do have these installed (Shih et al. 1980; U.S. EPA 1985).

Internal Combustion

Internal combustion sources include a wide variety of fuels, equipment designs and applications. A U.S. EPA review of internal combustion sources (Shih et al. 1979) identified gas turbines and reciprocating engines for electricity generation and industrial applications as having the most potential of the internal combustors for significant emissions of criteria pollutants.

Gas turbines include simple open cycle, regenerative open cycle and combined cycle turbines. The regenerative open cycle type is a very small portion of the total turbine population, and emissions from identical gas turbines used in the combined cycle and in the simple cycle are identical. Simple cycle gas turbines may be natural gas-fuelled or distillate oil-fuelled (diesel) (Shih et al. 1979).

Reciprocating engines are either spark ignition (gasoline-fuelled) or compression ignition (diesel-fuelled). Spark ignition engines are rarely used for electricity generation because of their poor part-load economy and cost of fuel (Shih et al. 1979).

Air emissions control equipment is not usually installed on gas turbines or reciprocating engines (Shih et al. 1979).

3.2.3   Inventory Method

Area source emissions from utility and industrial power generation are estimated using average emission factors by fuel type. The fuels considered are natural gas, coke oven gases, diesel fuel oil, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal and imported coal.

Uncontrolled CAC emission factors are from 2 major sources: Chapter 1 and 3 of U.S EPA's AP-42, 5th edition (1998), and U.S. EPA's FIRE 6.25 emission factor database (2004).   Emission factors were chosen to represent the typical type of combustion equipment for each fuel type.

Ammonia emission factors are from two separate sources by Battye et al (1994) and Coe et al (1996). CAC and ammonia emission factors are then summarized in Table 3.2-1.

Table 3.2-1: CAC Emission Factors for Electric Power Generation

Fuel	Emission factors (units as specified)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3
Natural gas (kg/GL)	121.7403[2]	121.7403[2]	121.7403[2]	9.6000[2]	4485.17[2]	88.1015[2]	1345.55[2]	54.4567
Coke oven gases (kg/GL)	121.7403[2]	121.7403[2]	121.7403[2]	9.6000[2]	4485.17[2]	88.1015[2]	1345.55[2]	54.4567
Diesel fuel oil (kg/kl)	0.2243[2]	0.2243[2]	0.2243[2]	16.8224S[2]	14.6572[2]	0.0068[2]	0.0550[2]	0.1198
Light fuel oil (kg/kl)	0.1797[2]	0.1198[2]	0.0300[2]	17.1591S[2]	2.8758[2]	0.0240[2]	0.5991[2]	0.1198
Heavy fuel oil (kg/kl)	1.101S + 0.385[2]	0.71TPM[2]	0.52TPM[2]	18.8127S[2]	5.6318[2]	0.0240[2]	0.5991[2]	0.1102
Coal Canadian bituminous (kg/t)	7.5000[1]	3.1000[1]	1.9000[1]	15.5S[1]	4.7500[1]	0.6500[1]	5.5000[1]	0.0003
Coal sub-bituminous (kg/t)	7.5000[1]	3.1000[1]	1.9000[1]	15.5S[1]	4.7500[1]	0.6500[1]	5.5000[1]	0.0003
Coal lignite (kg/t)	4.0000[1]	0.8000[1]	0.2800[1]	15S[1]	2.9000[1]	0.1000[1]	0.3000[1]	0.0003
Coal anthracite (kg/t)	0.4400[1]	0.1012[1]	0.0264[1]	19.5S[1]	4.6000[1]	0.1000[1]	0.3000[1]	0.0003
Coal imported bituminous (kg/t)	7.5000[1]	3.1000[1]	1.9000[1]	15.5S[1]	4.7500[1]	0.6500[1]	5.5000[1]	0.0003

Notes:
1.   AP-42 Chapter 1 or 3
2.   FIRE 6.25 database

Several emission factors are based on the weight percent of sulphur in the fuels. These are shown in Table 3.2-1 as the letter S. The sulphur contents of the fuels can change depending on the location of use. Sulphur contents of liquid fuels are given by the Fuels Division, Oil Gas & Energy Branch of Environment Canada (2004). Coal sulphur contents are derived from information given by the CEA Mercury Program (2005). Table 3.2-2 shows the sulphur content of each fuel in their respective province or territory.

Table 3.2-2: Sulfur Content in Fuel for Electric Power Generation

Fuel	Sulfur content in fuel (%)												
	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT	
Diesel fuel oil	0.11	011	0.11	0.11	0.273	0.276	0.207	0.207	0.207	0.207	0.207	0.207	
Light fuel oil	0.127	0.127	0.127	0.127	0.232	0.162	0.015	0.015	0.015	0.015	0.015	0.015	0.0
Heavy fuel oil	1.965	1.965	1.965	1.965	1.074	1.757	1.558	1.558	1.558	1.558	1.558	1.558	
Coal Canadian bituminous	7.00	7.00	7.00	7.00	1.6	1.55	0.3	0.3	0.02	0.2	0.2	0.0.2	
Coal sub-bituminous	2.373	2.373	2.373	2.373	0.2	0.375	0.45	0.2	0.267	0.2	0.2	0.2	
Coal lignite	0.40	0.40	0.40	0.40	0.4	0.6	0.4	0.562	0.6	0.6	0.6	0.6	
Coal anthracite	1.60	1.60	1.60	1.60	1.6	2.49	1.6	1.6	1.6	1.6	1.6	1.6	
Coal imported bituminous	1.5	1.5	1.5	1.5	1.5	0.94	1.5	1.5	1.5	1.5	1.5	1.5	

Uncontrolled toxic emission factors are from 4 major sources: Chapter 1 and 3 of U.S EPA's AP-42, 5th edition (1998), U.S. EPA's FIRE 6.25 emission factor database (2004), California Air Resources Board's (CARB) Air Toxic Emission Factor (CATEF) database, and a document titled Draft Dioxin Reassessment (US EPA, 2003). Emission factors were chosen to represent the typical type of combustion equipment for each fuel type. Tables 3.2-3 to 3.2-5 summarize the toxic emission factors chosen for each fuel.

Table 3.2-3: Heavy Metal Emission Factors for Electric Power Generation

Fuel	Emission factors (units as specified)		
	Hg	Cd	Pb
Natural gas (kg/GL)	4.165E-03[1]	1.762E-02[1]	8.009E-03[1]
Coke oven gases (kg/GL)	4.950E-2[2]	2.050E-02[2]	1.146[2]
Diesel fuel oil (kg/kl)	1.956E-05[3]	7.822E-05[3]	2.281E-04[3]
Light fuel oil (kg/kl)	3.247E-07[2]	3.894E-05[2]	7.285E-05[2]
Heavy fuel oil (kg/kl)	1.356E-05[1]	4.776E-05[1]	1.812E-04[1]
Coal Canadian bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal sub-bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal lignite (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal anthracite (kg/t)	6.500E-05[3]	3.550E-05[3]	4.450E-03[3]

Coal imported bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]

Notes:
1 AP-42 Chapter 1
2 CARB CATEF database
3. FIRE 6.25 database

Table 3.2-4: Dioxin and Furan Emission Factors for Electric Power Generation

Fuel	Emission factors (units as specified)	
	Power Generated by Utilities	Power Generated by Industry
Natural gas	0	0
Coke oven gases	0	0
Diesel fuel oil (ng I-TEQ/L oil)	0.2	0.2
Light fuel oil (ng I-TEQ/L oil)	0.2	0.2
Heavy fuel oil (ng I-TEQ/L oil)	0.2	0.2
Coal Canadian bituminous (ng I-TEQ/kg coal)	0.079	0.6
Coal sub-bituminous (ng I-TEQ/kg coal)	0.079	0.6
Coal lignite (ng I-TEQ/kg coal)	0.079	0.6
Coal anthracite (ng I-TEQ/kg coal)	0.079	0.6
Coal imported bituminous (ng I-TEQ/kg coal)	0.079	0.6

Notes:
Emission factors for dioxins and furans are from the Draft Dioxin Reassessment (2003)

Table 3.2-5: Polycyclic Aromatic Hydrocarbon Emission Factors for Electric Power Generation

Fuel	Emission factors (units as specified)			
	B(a)p	B(b)f	B(k)f	I(cd)p
Natural gas (kg/GL)	1.92E-05[2]	2.88E-05[2]	2.88E-05[2]	2.88E-05[2]
Coke oven gases (kg/GL)	6.920E-05[3]	1.583E-04[3]	8.602E-05[3]	6.696E-05[3]
Diesel fuel oil (kg/kl)	9.982E-06[3]	1.582E-05[3]	1.558E-05[3]	9.898E-06[3]
Light fuel oil (kg/kl)	1.61E-07[2]	1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Heavy fuel oil (kg/kl)	1.294E-07[3]	3.511E-06[3]	3.391E-06[3]	2.568E-07[2]

Coal Canadian bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal sub-bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal lignite (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal anthracite (kg/t)	Not emitted	Not Emitted	Not Emitted	Not Emitted
Coal imported bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]

Notes:
1. AP-42 Chapter 1
2. FIRE 6.25 database
3. CARB CATEF database

It must be noted that when anthracite coal is burned, polycyclic aromatic hydrocarbons are not emitted from electric power generation combustors.

3.2.4 Activity Level

Base quantities of fuel combusted for electric power generation by province/territory for 2006 were taken from Statistics Canada Catalogue No. 57-003-XIB. Growth factors where not used.

3.2.5 Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 2005 inventory for this sector. Actual data was available for 2006 and growth factors were not necessary.

3.2.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces/territories for this sector.

3.2.7 References

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3.2.8   Guidebook Sector Documentation Record

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Author: Kevin Chitamun, Pollution Data Division

NON-INDUSTRIAL FUEL COMBUSTION SECTOR

3.3   Residential Fuel Combustion-2006

3.3.1   General Description

Natural gas use for residential use is largest in Ontario, followed by Alberta and British Columbia. Light fuel oil use is highest in Quebec and Ontario, although light fuel oil is used in all provinces and territories except Nunavut. Consumption of coal for residential use is limited to Alberta and Saskatchewan. Agricultural consumption is minor for all gas and liquid fuel types, with no coal consumption.

3.3.2   Sector Description

Residential fuel combustion encompasses the combustion of fuels for the agricultural and residential sectors. There are 10 fuel types considered: natural gas, natural gas liquids, kerosene and stove oils, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal and imported coal. Residential wood combustion is discussed in section 3.4. Diesel and gasoline fuels are inventoried as off-road sources in the transportation sector (section 4.2).

Particulate matter, SO_2, NO_x, CO and VOCs are all emitted as a result of residential fuel combustion.

Distillate oil- and gas-fired residential furnaces have numerous burner configurations, designed to try to optimize the efficiency of fuel combustion. In natural gas-fired units, the fuel is usually premixed with excess air (commonly 10–15%) prior to injection in the burner to increase combustion efficiency. Distillate oil-fired units may use pressure or vaporization to atomize the fuel oil. This produces finer droplets for combustion, which usually increases combustion efficiency and decreases the formation of pollutants. Residual oil has little use in domestic applications, as it must be heated to facilitate handling and proper atomization (U.S. EPA 1998).

Residential coal-fired furnaces are usually underfeed or hand-stoked units. Boilers, used for steam or hot water production, and warm-air furnaces are usually stoker fed and automatically controlled by a thermostat. These are usually designed for a specific type of coal. Other hand-fed residential coal combustors, usually used for auxiliary heating, include room heaters, metal stoves and metal and masonry fireplaces. The majority of the coal burned for this purpose is bituminous or anthracite coal; lignite coal is an insignificant portion of the total (DeAngelis and Reznik 1979; U.S. EPA 1987).

Residential combustion units do not usually have particulate or gaseous pollutant control devices. However, proper design, use and maintenance of each unit can decrease the emissions. These involve changes in fuel properties (i.e., cleaning coal), fuel type, firing

rate, firing equipment design, modified combustion air flow control, better thermal control and heat storage and the cyclic operation of automatic equipment (DeAngelis and Reznik 1979; U.S. EPA 1998).

3.3.3 Inventory Method

Emissions from fuel combustion in the residential sector are estimated using emission factors by fuel type and fuel burning process. The fuels considered for estimation are natural gas, gas plant natural gas liquids, kerosene and stove oil, light fuel oil, heavy fuel oil, Canadian bituminous coal, sub-bituminous coal, lignite coal, anthracite coal and imported coals.

Uncontrolled CAC emission factors come from two US EPA sources. Natural Gas emission factors have been taken from the FIRE 6.25 emission factor database (2004), while all other CAC emission factors have been taken from Chapter 1 of the 5th edition AP-42 (1998). Emission factors were chosen to represent the typical type of combustion equipment for each fuel type.

Ammonia emission factors are from two separate sources by Battye et al (1994) and Coe et al (1996). CAC and ammonia emission factors are then summarized in Table 3.3-1.

Table 3.3-1: CAC & NH3 Emission Factors for Residential Fuel Combustion

Fuel	Emission factors (units as specified)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO	NH_3
Natural gas (kg/GL m^3)	121.7403	121.7403	121.7403	9.6000	1505.7	88.1015	640.731	8.3287
Natural gas liquids (kg/kl)	0.0550	0.0550	0.0550	0.0115	1.7500	0.0650	0.2500	0.0060
Kerosene and stove oil (kg/kl)	0.2400	0.1300	0.1000	17S[1]	2.4000	0.0410	0.6000	0.0960
Light fuel oil (kg/kl)	0.2400	0.1300	0.1000	17S	2.4000	0.0410	0.6000	0.1198
Heavy fuel oil (kg/kl)	1.12S + 0.37	0.62TPM	0.23TPM	19S	6.6000	0.1360	0.6000	0.1102
Coal Canadian bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003
Coal sub-bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003
Coal lignite (kg/t)	4A[2]	0.8A	0.28A	15S	2.9000	0.1000	0.3000	0.0003
Coal anthracite (kg/t)	0.44A	0.23TPM*A	0.06TPM*A	19.5S	4.6000	0.1000	0.3000	0.0003
Coal imported bituminous (kg/t)	7.5000	3.1000	1.9000	15.5S	4.7500	0.6500	5.5000	0.0003

Notes:
1. S means sulfur content in mass percent.
2. A is the ash content of the fuel. It is assumed to be 1%, or 1.

Several emission factors are based on the weight percent of sulphur in the fuels. These are shown in Table 3.3-1 as the letter S. The sulphur contents of the fuels can change depending on the location of use. Sulphur contents of liquid fuels are given by the Fuels Division, Oil Gas & Energy Branch of Environment Canada (2004). Coal sulphur contents are derived from information given by the CEA Mercury Program (2005). Table 3.3-2 shows the sulphur content of each fuel in their respective province or territory.

Table 3.3-2: Sulfur Content in Fuel for Residential Fuel Combustion

Fuel	Sulfur content in fuel (%)												
	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT	NU
Kerosene and stove oil	0.06	0.06	0.06	0.06	0.04	0.31	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Light fuel oil	0.13	0.13	0.13	0.13	0.23	0.16	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Heavy fuel oil	1.97	1.97	1.97	1.97	1.07	1.76	1.56	1.56	1.56	1.56	1.56	1.56	1.56
Coal Canadian bituminous	7.00	7.00	7.00	7.00	1.6	1.55	0.3	0.3	0.02	0.2	0.2	0.2	0.2
Coal sub-bituminous	2.37	2.37	2.37	2.37	0.2	1.38	0.45	0.2	0.26	0.2	0.2	0.2	0.2
Coal lignite	0.40	0.40	0.40	0.40	0.4	0.6	0.4	0.56	0.6	0.6	0.6	0.6	0.6
Coal anthracite	1.60	1.60	1.60	1.60	1.6	2.49	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Coal imported bituminous	1.5	1.5	1.5	1.5	1.5	0.94	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Uncontrolled toxic emission factors are from 4 major sources: Chapter 1 of U.S EPA's AP-42, 5th edition (1998), U.S. EPA's FIRE 6.25 emission factor database (2004), California Air Resources Board's (CARB) Air Toxic Emission Factor (CATEF) database, and a document titled Draft Dioxin Reassessment (US EPA, 2003). Emission factors were chosen to represent the typical type of combustion equipment for each fuel type. Tables 3.3-3 to 3.3-5 summarize the toxic emission factors chosen for each fuel.

Table 3.3-3: Heavy Metal Emission Factors for Residential Fuel Combustion

Fuel	Emission factors (units as specified)		
	Hg	Cd	Pb
Natural gas (kg/GL m^3)	4.165E-03[1]	1.762E-02[1]	8.009E-03[1]
Natural gas liquids (kg/kl)	0[2]	1.430E-01[2]	1.146[2]
Kerosene and stove oil (kg/kl)	3.247E-07[2]	3.894E-05[2]	7.285E-05[2]
Light fuel oil (kg/kl)	3.247E-07[2]	3.894E-05[2]	7.285E-05[2]
Heavy fuel oil (kg/kl)	1.356E-05[1]	4.776E-05[1]	1.812E-04[1]
Coal Canadian bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal sub-bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal lignite (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]
Coal anthracite (kg/t)	6.500E-05[3]	3.550E-05[3]	4.450E-03[3]
Coal imported bituminous (kg/t)	4.147E-05[1]	2.548E-05[1]	2.098E-04[1]

Notes:
1. AP-42 Chapter 1
2. CARB CATEF database
3. FIRE 6.25 database

Table 3.3-4: Dioxin and Furan Emission Factors for Residential Fuel Combustion

Fuel	Emission factors (units as specified)
	I-TEQ Dioxin & Furan
Natural gas (ng/L)	0
Natural gas liquids (ng/L)	0
Kerosene and stove oil (ng/L)	0.15
Light fuel oil (ng/L)	0.15
Heavy fuel oil (ng/L)	0.15
Coal Canadian bituminous (ng/kg)	7.5
Coal sub-bituminous (ng/kg)	7.5
Coal lignite (ng/kg)	7.5
Coal anthracite (ng/kg)	2.1
Coal imported bituminous (ng/kg)	7.5

Notes:

Emission factors for dioxins and furans are from the Draft Dioxin Reassessment (2003)

Table 3.3-5: Poly Aromatic Hydrocarbon Emission Factors for Residential Fuel Combustion

Fuel	Emission factors (units as specified)			
	B(a)p	B(b)f	B(k)f	I(cd)p
Natural gas (kg/GL m^3)	1.92E-05[2]	2.88E-05[2]	2.88E-05[2]	2.88E-05[2]
Natural gas liquids (kg/kl)	0	0	0	0
Kerosene and stove oil (kg/kl)	1.61E-07[2]	1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Light fuel oil (kg/kl)	1.61E-07[2]	1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Heavy fuel oil (kg/kl)		1.78E-07[1]	1.78E-07[1]	2.57E-07[1]
Coal Canadian bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal sub-bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal lignite (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]
Coal anthracite (kg/t)	2.65E-06[2]	1.25E-05[2]	1.25E-05[2]	3.45E-06[2]
Coal imported bituminous (kg/t)	1.90E-08[1]	5.50E-08[1]	5.50E-08[1]	3.05E-08[1]

Notes:
1. AP-42 Chapter 1
2. FIRE 6.25 database

3.3.4   Activity Level

Base quantities of fuel combusted in residential/agricultural boilers by province/territory for 2006 were taken from Statistics Canada Catalogue No. 57-003-XIB for the sectors listed in Table 3.3-6.

Table 3.3-6: Statistics Canada Sector Definitions[1]

Sectors	Definition
Agricultural	Establishments engaged in agricultural activity as well as those engaged in providing services to agriculture. Includes mushroom growers, greenhouses and nurseries.
Residential	Includes all residences; homes, duplexes, apartments, apartment hotels, condominiums and farm homes.

Note:
1. See Definitions section of Catalogue No. 57-003-XIB.

3.3.5   Comparison of 2006 Methods with Previous Methodology

Updated sulphur contents, and growth factors were not needed due to actual 2006 activity levels.

3.3.6   Alternative Methods Used by Provinces/Territories

There were no alternate methods used by provinces or territories.

3.3.7 References

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3.3.8 Guidebook Sector Documentation Record

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NON-INDUSTRIAL FUEL COMBUSTION SECTOR

3.4   RESIDENTIAL FUELWOOD COMBUSTION

3.4.1   General Description

There are three basic types of residential wood combustors: stoves, fireplaces and furnaces.

Emissions of particulate matter, CO, NO_x, SO_x, and VOC, hevy metals, dioxins and furans and PAHs are all inventoried for residential fuel wood combustion. VOCs, CO, and particulate matter from these sources form a significant portion of Canadian emissions.

3.4.2   Sector Description

The main types of residential wood combustion devices that are considered in this sector are stoves, fireplaces, furnaces, cook stoves and pellet stoves.

Emissions that are covered include TPM, PM_{10}, $PM_{2.5}$, CO, NO_x, NH_3, SOx, VOC, heavy metals, dioxins and furans, and PAHs. The emission estimates were derived using the best available information and will be revised as better information becomes available.

Residential Wood Stoves

Wood stoves are free-standing space heating appliances. Used either as the principal source of heat for a home or to supplement conventional heating systems, wood stoves are the most popular form of wood heating equipment because of their relatively low cost and installation flexibility (Natural Resources Canada and Canada Mortgage and Housing Corporation 1995).

Based on variations in construction, combustion technology and emission characteristics, residential wood stoves have been grouped in the following categories: conventional wood stoves, advanced combustion wood stoves and masonry heaters.

Conventional stoves do not incorporate the advanced combustion technologies needed to meet emission standards (see discussion below). This category would include older cast iron box stoves, parlour stoves, Franklin fireplaces and the so-called "airtights" of the 1970s and 1980s.

Advanced combustion wood stoves are defined as those that meet the emission limits prescribed by the U.S. EPA or the CSA B415 standard and are certified by one of these agencies or other suitably accredited agencies. The U.S. EPA and CSA emission testing requirements measure and report on particulate emissions as a surrogate for all other pollutants. The two standards are virtually identical to facilitate bilateral trade.

Manufacturers use one of two general approaches to achieve lower stack emissions based on whether or not they use a catalytic element.

A typical non-catalytic advanced combustion design includes an insulated primary combustion chamber, a comprehensive internal baffle, which acts as a reflective surface and separates the primary combustion chamber from the secondary combustion chamber, and a system to preheat and distribute a secondary air supply.

A catalytic stove is equipped with a ceramic combustor coated with platinum or palladium located in the appliance downstream of the primary combustion chamber. The catalyst reduces the ignition temperature of the unburned products of primary combustion, thus promoting secondary combustion and reducing particulate emissions at normal stove operating temperatures.

Both catalytic and non-catalytic designs have proved successful in achieving lower emissions, but their performance profiles differ. A typical catalytic stove will produce low emissions when new; as the catalyst performance degrades with age, average emissions will rise. Complete servicing after several years of use, including a replacement catalytic element, will restore performance to approximately that of a new stove. For this reason, the U.S. EPA and CSA certification requirements for catalyst-equipped stoves are more stringent than those for non-catalytic stoves, which do not display the same performance degradation with age. In practical terms, however, the emissions performance of catalytic and non-catalytic systems can be considered the same. Advanced combustion wood stoves first became available in the mid-1980s, but they were not widely accepted until they were clearly identified as meeting the mandatory certification requirements of the U.S. EPA in the late 1980s (Natural Resources Canada and Canada Mortgage and Housing Corporation 1995; Gulland Associates Inc. 1997; Wood Energy Technology Transfer Inc. 1998).

A masonry heater is a traditional space heating system of European origin that has been adapted for North American conditions. It has an enclosed combustion chamber in which a charge of wood is burned rapidly. The hot exhaust gases are routed through heat transfer channels embedded in the massive masonry structure before being expelled to the chimney. The heat stored in the masonry is released slowly to the room for up to 24 hours after combustion of the wood is complete. Relatively complete combustion is achieved through the rapid, turbulent combustion that is characteristic of masonry heaters (Natural Resources Canada and Canada Mortgage and Housing Corporation 1995).

Residential Fireplaces

The term fireplace was traditionally used to describe a wood-burning device built into the structure of a living area and in which the fire can be viewed while it burns. However, the distinction between wood stoves and fireplaces is no longer as clear as it once was. For example, virtually all advanced wood stoves have glass panels in their doors and incorporate a technology that sweeps combustion air behind the glass to keep it clear for effective fire viewing. Also, some fireplaces now have advanced combustion

technologies that permit them to meet U.S. EPA/CSA emission limits and can have heat ducts connected for use as central heating systems. As well, some masonry heaters look like fireplaces but have the efficiency and low emissions of advanced wood stoves. Therefore, the term fireplace must be used with some caution. It is used here to mean a device that is not free-standing but is built into the wall of a living space. The term does not refer to strictly decorative appliances.

Fireplaces can be divided into two broad categories:

- masonry fireplaces, which are constructed of brick, stone or other masonry materials, assembled on site and usually connected to a masonry chimney; and
- factory-built (also called prefabricated and informally as zero-clearance) fireplaces, in which the structural material is usually metal and the fireplace is installed on site as a package with the specified metal chimney.

Conventional fireplaces, whether masonry or factory-built, do not incorporate emission reduction technologies and may or may not have glass doors. Generally, conventional fireplaces are not effective for home heating purposes because of high-dilution air demands and inadequate heat transfer characteristics. Some masonry and virtually all factory-built conventional fireplaces incorporate an air circulation jacket around the firebox connected to grilles that take air from floor level, heat it and return it to the room. However, these air circulation systems are rarely effective enough to overcome the other limitations inherent in conventional designs and are used mainly to permit reduced clearances to combustible material by cooling the outer skin of the fireplace rather than for space heating (Natural Resources Canada and Canada Mortgage and Housing Corporation 1995; Gulland Associates Inc. 1997; Wood Energy Technology Transfer Inc. 1998).

Fireplace inserts are essentially wood stoves that have been adapted by their manufacturers to fit within the firebox of masonry fireplaces. A few inserts are certified for and installed in factory-built fireplaces. An insert converts a conventional fireplace into an effective heating system. Both conventional and advanced technology fireplace inserts have been on the market, and their emissions performance can be assumed to be the same as those of conventional and advanced wood stoves (Canadian Facts 1997; National Forestry Database 1997).

Central Heating Furnaces and Boilers

Wood-fired central heating systems are available in several forms: add-on warm air furnaces for connection to existing oil or electric furnaces; combination furnaces that use electricity or burn oil in addition to wood; and boilers that heat water and use a system of pipes to distribute heat. There are no advanced technology central systems available in Canada, so all furnaces and boilers tend to produce relatively high smoke emissions. The use of wood-fired central systems, with the exception of outdoor boilers, has been declining for almost 20 years (Natural Resources Canada and Canada Mortgage and Housing Corporation 1995; Gulland Associates Inc. 1997; Wood Energy Technology Transfer Inc. 1998).

Outdoor boilers have been gaining popularity over the past decade, particularly in rural Manitoba and Ontario, and are more recently being sold in the Atlantic provinces. An outdoor boiler is enclosed in a small shed and uses insulated underground piping to deliver heat to the house. In the development of this inventory, it is assumed that users of outdoor boilers would have responded that they used a furnace or "other" wood-burning device (Gulland Associates Inc. 1997).

Other Wood Combustion Devices

Pellet stoves are fuelled with pellets of sawdust or other waste biomass materials compressed into small cylinders about 8 mm in diameter and from 10 to 30 mm in length. The raw feedstock for pellet production does not include binders or other additives, except in some cases to assist in the extrusion process. In the pellet stove, the fuel is moved from the integral hopper to the small combustion chamber by a motorized auger. The exhaust is forced into the vent with a fan. Because steady-state combustion can be approximated by adjusting the fuel and air mixture, pellet stoves can burn with lower emissions, on average, than wood stoves. In contrast, the combustion of a batch of wood in a wood stove never stabilizes, so combustion air requirements are constantly fluctuating and good combustion conditions are transitory (Natural Resources Canada and Canada Mortgage and Housing Corporation 1995; Gulland Associates Inc. 1997; Wood Energy Technology Transfer Inc. 1998).

A wood cooking range is a specialized appliance that uses wood fuel to heat a cook-top surface, a bake oven and sometimes a reservoir for domestic hot water. Cook ranges are not common in Canada, although a few models are still available for sale in specialty stores. Cooking ranges are exempt under the U.S. EPA wood-burning regulations because the numbers were considered small and their manufacturers testified that practical cooking features and low-emission combustion technology are incompatible. No specific emissions performances for cooking ranges were found in the literature, but particulate emissions are probably similar to those of conventional wood stoves (Natural Resources Canada and Canada Mortgage and Housing Corporation 1995; Gulland Associates Inc. 1997; Wood Energy Technology Transfer Inc. 1998).

3.4.3 Inventory Method

Since detailed information on the frequency and distribution of the appliance categories and average fuel consumption for each was not available from other sources, a survey was commissioned by Environment Canada in the spring of 2006 similar to the survey conducted in 1997. The survey data permitted more precise allocation of estimated emissions among appliance categories and regions of Canada.

The emissions from residential fuelwood combustion were calculated by multiplying the estimated annual consumption of firewood by average emission factors for each appliance category. Emission factors for each of the combustion device categories described in the previous section were then used to estimate the total emissions. The

emission factors for TPM, PM_{10}, $PM_{2.5}$, CO, NO_x, SO_x, VOC, heavy metals, dioxins and furans, and PAHs were obtained from a large number of sources (see references in section 3.4.7).

It should be noted that both requirements for the development of this emissions inventory (wood consumption and emission factors) are difficult to establish and have associated uncertainties. Estimates of wood consumption may be uncertain because:

- this sector consists of over three million point sources in Canada;
- the fuel is either acquired by the householder or supplied by an industry that is largely informal and unregulated; and
- the estimation of total annual firewood consumption poses a number of challenges to survey researchers (as discussed in section 3.4.4).

Emission factors may be uncertain because of the following:

- Residential wood combustion technology exists in a number of significantly different appliance categories, each with a somewhat different usage pattern, and within these categories there are wide differences in combustion design and therefore emission profiles.
- Most residential wood burning involves the essentially random combustion of batches of fuel. Hence, steady-state combustion is not maintained, resulting in inherent difficulties in the measurement of emissions.
- Universally accepted test protocols have not been developed. Various test protocols have been devised to measure residential wood combustion emissions with acceptable precision and repeatability. In order to apply sufficient data to the development of an emission factor for each appliance category, correlations must be made between different methodologies used for certification purposes in laboratory settings and in various field research studies (Houck and Tiegs 1998).

As a result of the inherent difficulties in developing the emissions inventory for this sector, considerable effort has been expended in identifying information sources and in consulting with specialists in the residential wood combustion, emissions testing and survey research sectors.

Emission factors for criteria air contaminants for the categories of wood-burning appliances are presented in Table 3.4-1.

Table 3.4-1: Criteria Air Contaminant Emission Factors for Residential Wood Combustion[1]

Combustor	Emission factors (kg/t of dry fuel)								
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3	Notes
Wood-burning fireplaces									
Conventional fireplaces									
Without glass doors	19.3	18.5	18.4	0.2	1.4	6.5	77.7	0.1260	2
With glass doors	13.5	13.0	12.9	0.2	1.4	21.0	98.6	0.1260	2
Fireplaces with an insert									
Conventional	14.4	13.6	13.6	0.2	1.4	21.3	115.4	0.1260	3
Advanced technology	5.1	4.8	4.8	0.2	1.4	7.0	70.4	0.1260	3
Advanced technology fireplaces	5.1	4.8	4.8	0.2	1.4	7.0	70.4	0.1260	4
Wood-burning stoves									
Conventional stoves									
Not airtight	24.6	23.2	23.2	0.2	1.4	35.5	100	0.1260	5
Airtight	14.4	13.6	13.6	0.2	1.4	21.3	115.4	0.1260	5
Advanced technology stoves	5.1	4.8	4.8	0.2	1.4	7.0	70.4	0.1260	5
Central furnaces/boilers	14.1	13.3	13.3	0.2	1.4	21.3	68.5	0.1260	6
Pellet stoves	1.2	1.1	1.1	0.2	1.4	1.5	8.8		7
Other wood-burning equipment	14.4	13.6	13.6	0.2	1.4	21.3	115.4	0.1260	5, 6

Notes:

1. Assistance in the identification and review of documents and recommendations for the development of emission factors were provided by Dr. James E. Houck, Vice President of Research, OMNI Environmental Services Inc., Beaverton, Oregon.
2. The emission factors for conventional fireplaces with and without doors were developed from an analysis of many studies, since no single definitive study exists. There is no widely recognized test protocol for conventional fireplaces, so different fuels, load configurations and test procedures are used in various studies. As a result, each of the studies analyzed provides only emission results under specific conditions and may provide only context for findings from other studies.
3. Emission factors for fireplace inserts are the same as for the corresponding free-standing wood stoves. See Note 5 below for discussion of data used in the development of these emission factors.
4. Advanced technology fireplaces may be treated the same as advanced wood stoves since they meet the same emission standard and their emission control technologies are similar. See Note 5 below.
5. Emission factors for conventional and advanced wood stoves, fireplace inserts and advanced fireplaces were developed from an analysis of many studies. Although different emission factors are sometimes reported in the literature, the emissions for catalytic and non-catalytic advanced wood stoves are combined in a single average factor to reflect the long-term performance profiles of these two emission reduction technologies. Correcting to account for differences in test methods and adjusting for higher burn rates recorded during field testing, the particulate matter emission factor for new catalytic stoves would be 3.2 g/kg of fuel burned, and for non-catalytic stoves, the factor would be 5.1 g/kg. Therefore, to avoid the potential for distortion of total emissions for the entire population of advanced stoves and to account for the fact that the majority of advanced stoves used in Canada are of the non-catalytic type, the single emission factor for non-catalytic stoves is used.
6. The emission factors for central furnaces and boilers were based on the analysis of the few available studies. One of the referenced studies reported on testing of two outdoor boilers. Therefore, the emissions performance of these systems is reflected in the average emission factors for central furnaces and boilers.
7. The emission factors for pellet stoves were developed from the analysis of several studies. However, because of the relatively small number of pellet stoves in use in Canada and because the surveys used did not specifically ask respondents if their appliances burned pellets, it was not possible to develop a useful estimate of the number of pellet stoves in use. The emission factors are provided here for information only and may be useful in the future if a better estimate of the number of pellet stoves in use is developed.

The emission factors presented in the table differ from those published by the U.S. EPA in the relevant AP-42 documents for the following reasons:

- The emission factors developed for this inventory are based on a larger number of studies and more recent studies than those cited in AP-42. Although the AP-42 documents are dated 1996, the most recent actual adjustment of the factors was in 1992 and was based on results of earlier studies (Houck and Tiegs 1998).
- The AP-42 emission factors assumed that all particulate emissions are PM_{10}. This distorts the figures by about 10%.

The AP-42 factors are presented in U.S. EPA Method 5H equivalent values (gas bubbled through ice water bath), but most laboratories certifying stoves use the 5G train consisting of a dilution tunnel and dry filters. Both 5H and 5G methods are laboratory test methods. A number of methods have been used to measure real-world emissions produced by stoves operated by householders, the most common of which is the Automated Woodstove Emission Sampler developed by OMNI Environmental Services. Since the various methods do not yield precisely the same results, correction factors have been used in an attempt to make the results comparable. The correction factors used for analysis reported in AP-42 have been found faulty. The correction factors applied to emission test results for the development of this inventory are based on the best professional judgement of the most experienced residential wood combustion researchers and regulatory specialists in North America and are based partly on data produced since the most recent U.S. EPA AP-42 reports were published (Houck and Tiegs 1998).

The AP-42 emission factors for conventional airtight and non-airtight wood stoves were based on old studies in which the stoves tested were not a good fit within the categories. The emission factors provided here are based on more studies and more accurate fitting of stoves within categories (U.S. EPA 1996a and b, U.S. EPA 1999a and b; Correll et al. 1997; Houck and Tiegs 1998; Fisher et al. 1999).

Although there is no precise relationship for all appliances, the levels of particulate matter and CO emissions tend to be related to both the completeness of combustion and the availability of oxygen during combustion. As a result, fireplaces without doors and non-airtight wood stoves can have higher particulate matter emissions and lower CO emissions than fireplaces with doors or airtight wood stoves. These relationships may appear to be anomalous but are actually due to the refinement of earlier emission factor estimates.

The dioxins and furans emission factor of 0.5 ng/kg was obtained based on a series of tests was conducted in early 2000 at the ITS laboratory in Montreal under the auspices of Environment Canada in consultation with the Hearth Products Association of Canada.

3.4.4   Activity Level

Wood Consumption Estimate Development

To develop the emission estimates from residential wood burning across Canada, a survey was commissioned by Environment Canada to collect information on:

- the number and types of combustion devices in use;
- the geographic distribution of wood-burning devices; and
- provincial fuelwood consumption.

The survey was conducted in the spring of 2006 through Canadian Facts of Toronto. The survey was mailed out to 19,740 households as part of a Canadian Family Opinion panel of Canadian Facts. In total, 9,588 responses were received and processed.

At the tabulation stage, the completed questionnaires were weighted into their correct proportions: first by age within type of family by province, and second by size of household within region by community size, based on the most recently available census data. No differentiation was made between single and multiple family dwellings (Canadian Facts 2006).

Table 3.4-2 provides a summary of the survey responses received in each of the provinces through the Canadian Facts survey. Table 3.4-3 provides a summary of the total wood in provinces based on the survey.

Table 3.4-2: Number of Actual and Weighted Provincial Surveys Received[1]

Province	Actual Completions #	Weighted Completions #
Newfoundland	281	174
Nova Scotia	54	33
New Brunswick	618	313
Prince Edward Island	354	245
Quebec	2021	2530
Ontario	2907	3492
Manitoba	574	400
Saskatchewan	588	305
Alberta	874	905
British Columbia	1316	1192
Total	9587	9587

Note:
  1. Reference: Canadian Facts (2006).

Table 3.4-4 provides information on the provincial/territorial percentage distribution of wood consumed by appliance type. This information, combined with the calculated tonnage of wood consumed by province/territory (Table 3.4-3), resulted in the provincial/territorial wood consumption estimates by device type provided in Table 3.4-5.

Due to the very small sample size and the small quantity of wood usage obtained from the Canadian Facts survey for Yukon, Nunavut and Northwest Territories, no activity level estimation was performed..

Table 3.4-3: Summary of Wood Burned based on the Survey

Province	Total Wood Burned tonnes
Newfoundland	339,600
Prince Edward Island	56,600
Nova Scotia	403,275
New Brunswick	374,975
Quebec	3,459,675
Ontario	1,648,475
Manitoba	162,725
Saskatchewan	127,350
Alberta	233,475
British Columbia	749,950
Canada	7,556,100

Table 3.4-4: Provincial/Territorial Distribution of Wood Consumption by Device Type[1]

Source type	Wood consumption (%)[2]											
	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT[3]
Wood-burning fireplaces												
Conventional fireplaces												
Without glass doors	0.94	1.7	3.33	2.45	6.61	9.93	7.46	6.82	25.44	14.65	1.77	1.77
With glass doors	1.13	2.65	2.83	2.49	9.76	11.45	8.65	14.35	22.99	10.61	2.76	2.76
Fireplaces with an insert												
Conventional	0.19	0	1.67	1.32	1.36	4.68	2.34	1.92	2.56	6.57	0.79	0.79
Advanced technology	0.41	0	0	0	0.72	1.06	0	0	1.97	0.85	0.10	0.10
Advanced technology fireplaces	0	2.18	0.98	0.74	1.99	0.86	0.67	1.77	2.38	1.00	0.99	0.99
Wood-burning stoves												
Conventional stoves												
Not airtight	19.06	13.23	11.83	12.45	12.47	13.15	20.14	13.01	15.39	19.39	13.75	13.75
Airtight	28.07	32.00	37.52	37.64	35.01	35.57	27.11	31.30	17.62	28.98	33.26	33.26
Advanced technology stoves	4.52	7.27	2.71	3.25	9.96	4.72	6.64	7.75	7.38	5.26	4.50	4.50
Central wood-burning furnaces/boilers	45.67	39.98	37.74	39.00	21.28	16.75	25.23	22.58	2.23	9.86	41.56	41.56
Other wood-burning equipment		0.98	1.38	0.66	0.83	1.82	1.77	0.50	2.04	2.82	1.02	1.02

Notes:
1. Reference: Infometrica (1998).
2. Blanks or zeros mean that none is reported rather than none is used in the province/territory.
3. NT includes NU.

Table 3.4-5: Wood Consumption by Province/Territory and Stove Type

Source Type	Wood Consumption											
	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT[1]
Wood Burning Fireplaces (Total)												
Conventional Fireplaces												
Without Glass Doors	3,192	965	13,429	9,187	228,685	163,694	12,139	8,685	59,396	109,868	144	315
With Glass Doors	3,837	1,502	11,413	9,337	337,664	188,750	14,076	18,275	53,676	79,570	225	490
Fireplaces With an Insert												
Conventional	645	0	6,735	4,950	47,052	77,149	3,808	2,445	5,977	49,272	64	140
Advanced Technology	1,392	0	0	0	24,910	17,474	0	0	4,599	6,375	8	18
Advanced Tech. Fireplaces	0	1,234	3,952	2,775	68,848	14,177	1,090	2,254	5,557	7,500	81	176
Wood Burning Stoves (Total)												
Conventional Stoves												
Not Air Tight	64,728	7,487	47,707	46,684	431,421	216,774	32,773	16,568	35,932	145,415	1,122	2,443
Air-Tight	95,326	18,109	151,309	141,141	1,211,232	586,363	44,115	39,861	41,138	217,336	2,713	5,910
Advanced Tech. Stoves	15,350	4,117	10,929	12,187	344,584	77,808	10,805	9,870	17,230	39,447	367	800
Central Furnaces/Boilers	155,129	22,630	152,196	146,240	736,219	276,120	41,056	28,756	5,206	73,945	3,390	7,385
Other Equipment	0	555	5,606	2,475	29,061	30,167	2,864	637	4,763	21,224	83	181
Total	339,600	56,600	403,275	374,975	3,459,675	1,648,475	162,725	127,350	233,475	749,950	8,199	17,859

Note:
1. NT includes NU.

3.4.5 Comparison of 2006 Methods with Previous Methodology

There was no change in the emission factors for the 2005.

3.4.6 Alternative Methods Used by Provinces/Territories

There were no alternate area source methodologies used by the provinces.

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3.4.8   Guidebook Sector Documentation Record

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CHAPTER 4
TRANSPORTATION SECTOR

TRANSPORTATION SECTOR

4.1   ON-ROAD VEHICLES

4.1.1   General Description

This sub-sector covers CAC emissions from vehicles licensed for use on road (paved and unpaved) to transport people and/or goods. Emissions of all CACs from this sub-sector result from the combustion of fossil fuels in internal engines, evaporation of those fuels through the fuel system and from tire- and brake wear. Emission estimates were generated on a provincial/territorial level and on a monthly basis, then summed to get annual provincial/territorial level estimates. In the case of British Columbia and Ontario, estimates were generated at a greater level of detail, sub-dividing Ontario into four Phases, and British Columbia into three Phases, to properly capture the effects of the inspection and maintenance programs in each province. British Columbia's Phases are based on the report *2004 Rates Schedule, Rate Class & Territory* (Insurance Corporation of British Columbia, 2003). Ontario's Phases are based on counties and the Drive Clean catchment areas. :

4.1.2   Sector Description

The vehicle classes are those in the emission factor model MOBILE6.2C, and are based on gross vehicle weight rating (GVWR) and loaded vehicle weight (LVW). The MOBILE6.2C labels are defined below.

LDGV	Light-Duty Gas Vehicles (passenger cars)
LDGT1	Light-Duty Gas Trucks Class 1 (0-6,000 lbs. GVWR, 0-3750 lbs. LVW)
LDGT2	Light Duty Gas Trucks Class 2 (0-6,001 lbs. GVWR, 3751-5750 lbs. LVW)
LDGT3	Light Duty Gas Trucks Class 3 (6,001-8500 lbs. GVWR, 0-3750 lbs. LVW)
LDGT4	Light Duty Gas Trucks Class 4 (6,001-8500 lbs. GVWR, 3751-5750 lbs. LVW)
HDGV2B	Heavy Duty Gas Vehicles Class 2b (8501-10,000 lbs. GVWR)
HDGV3	Heavy Duty Gas Vehicles Class 3 (10,001-14,000 lbs. GVWR)
HDGV4	Heavy Duty Gas Vehicles Class 4 (14,001-16,000 lbs. GVWR)
HDGV5	Heavy Duty Gas Vehicles Class 5 (16,001-19,500 lbs. GVWR)
HDGV6	Heavy Duty Gas Vehicles Class 6 (19,501-26,000 lbs. GVWR)
HDGV7	Heavy Duty Gas Vehicles Class 7 (26,001-33,000 lbs. GVWR)
HDGV8A	Heavy Duty Gas Vehicles Class 8a (33,001-60,000 lbs. GVWR)
HDGV8B	Heavy Duty Gas Vehicles Class 8b (>60,000 lbs. GVWR)
LDDV	Light-Duty Diesel Vehicles (passenger cars)
LDDT12	Light-Duty Diesel Trucks Class 1 and 2 (0-6,000 lbs. GVWR, 0-5750 lbs. LVW)
HDDV2B	Heavy Duty Diesel Vehicles Class 2b (8501-10,000 lbs. GVWR)
HDDV3	Heavy Duty Diesel Vehicles Class 3 (10,001-14,000 lbs. GVWR)
HDDV4	Heavy Duty Diesel Vehicles Class 4 (14,001-16,000 lbs. GVWR)
HDDV5	Heavy Duty Diesel Vehicles Class 5 (16,001-19,500 lbs. GVWR)
HDDV6	Heavy Duty Diesel Vehicles Class 6 (19,501-26,000 lbs. GVWR)
HDDV7	Heavy Duty Diesel Vehicles Class 7 (26,001-33,000 lbs. GVWR)
HDDV8A	Heavy Duty Diesel Vehicles Class 8a (33,001-60,000 lbs. GVWR)
HDDV8B	Heavy Duty Diesel Vehicles Class 8b (>60,000 lbs. GVWR)
MC	Motorcycles
GAS BUS	Gasoline-fuelled Bus
URB BUS	Transit and Urban Bus
SCH BUS	School Bus
LDDT34	Light-Duty Diesel Trucks Class 3 and 4 (6,001-8500 lbs. GVWR, 0-5750 lbs. LVW)

These classes are often aggregated back to the MOBILE5 vehicle class structure.

HDDV	Heavy-duty diesel powered vehicles (8501 lbs. and greater, GVWR)
HDGV	Heavy-duty gasoline powered vehicles (8501 lbs. and greater, GVWR)
LDDT	Light-duty diesel powered trucks (0-8500 lbs., GVWR)
LDDV	Light-duty diesel powered vehicles (passenger pars)
LDGT	Light-duty gasoline powered trucks (0-8500 lbs., GVWR)
LDGV	Light-duty gasoline powered vehicles (passenger cars)
MC	Motorcycles (all motorcycles are assumed to be gasoline powered)

4.1.3   Inventory Method

Emission estimates from on-road vehicles were generated using a bottom-up approach; developing emission factors and applying them to activity data. Generally, emission factors were developed using MOBILE6.2C and the activity level was the number of vehicle kilometres traveled. Environment Canada modified the United States Environmental Protection Agency (EPA) MOBILE6.2 model to better reflect Canadian conditions. The model was named MOBILE6.2C.

Emissions factors for fine particulate matter (PM10 and PM2.5); sulphur oxides (SOx); oxides of nitrogen (NOx); volatile organic compounds (VOCs); carbon monoxide (CO); and ammonia (NH3) were estimated using the MOBILE6.2C model. MOBILE6.2C also produced emission factors of the heavy-metals, PAHs, and toxics. For Environment Canada's 2006 CAC Inventory, the model version used was "27-May-2005"; input files were date-stamped in October/December 2005 and given a reference number with a hyphen "6", indicating an in-house naming convention for "version six". Some input files will be version6, some will be version6.2. Total particulate matter (TPM) was estimated from MOBILE's PM10 estimate, using the EPA's *PM Calculator* tool. Dioxin and furan emission factors were taken from the report *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds* (EPA, 2000). MOBILE is a sophisticated model that requires a number of inputs to more accurately estimate emission factors. Input files were created for MOBILE6.2C to account for the emission impacts of the vehicle fleet profile (populations, age distribution), vehicle emission standards, meteorological and fuel characteristics, and other factors.

Data on the vehicle fleet, defined by fuel type, model year and gross vehicle weight rating come from DesRosiers Automotive Consultants, and R. L. Polk & Co., for light- and heavy-duty vehicles respectively. Motorcycle populations come from publication *Road Motor Vehicles Registrations* (Statistics Canada, annual) and the *Motorcycle & All-Terrain Vehicle Annual Industry Statistics Report* (Motorcycle and Moped Industry

Council, 2003). Bus populations were based on the *Comprehensive Energy Use Database* (Natural Resources Canada/Office of Energy Efficiency, 2005).

For the cases of Ontario and British Columbia, the provinces provided access to vehicle registration data, including vehicle identification numbers (VINs). Access to VIN data is essential to properly decode VINs into the correct MOBILE vehicle classes. Registration information also allowed for the determination of the vehicles that would be included in the inspection and maintenance (I/M) programs in each province. VIN decoding and I/M reductions were estimated in the report *Vehicle Fleet Profiles for Ontario and British Columbia* (Stewart-Brown Associates, 2004).

Since 1971, the Canadian Government has adopted increasingly stringent standards to control smog-forming emissions from new on-road vehicles, including hydrocarbons, carbon monoxide, oxides of nitrogen and particulate matter. Canada's emission standards have generally been aligned with those of the U.S. EPA. This has been accomplished through a combination of regulations and memoranda of understanding with vehicle and engine manufacturers. There are, however, times were the standards were different in Canada and the United States. This was the basis for the Canadian conversion of MOBILE6.2, where basic emission rates were modified to appropriately reflect the impact of the differences in emission standards between Canada and the United States on the emission characteristics of the Canadian fleet. In most cases, a high penetration of vehicles meeting U.S. emission standards is assumed in years where Canada's emission standards may have lagged behind those of the U.S., given the highly integrated nature of the North American automotive manufacturing industry.

Meteorological data come from Meteorological Services Canada. For each province/territory/region, the largest city by population is selected. For each of these cities, the largest airport (international if possible) is selected as the station from which to draw meteorological data. Airports are used because there is one in each city, and because they often contain the most complete and longest-running datasets. The meteorological data for the city is assigned to the entire province/territory/region, under the assumption that the bulk of the vehicle kilometres traveled are within the largest city. The meteorological stations used in Environment Canada's 2006 CAC Inventory are listed in **Appendix D** of this report. Monthly maximum and minimum temperatures are integrated into the input file, to align with "summer" and "winter" fuel properties. October 1 through April 31 get 'winter' fuel properties; May 1 through September 31 get 'summer' fuel properties (or special RVPs where applicable). On-road diesel and gasoline sulphur levels, in parts per million (ppm), come from the report *Sulphur in Liquid Fuels* (Environment Canada's Oil, Gas and Energy Branch, annual). All other fuel characteristics, such as Reid Vapour Pressure (RVP) and oxygenates, were obtained from the report *Emissions of Air Toxics from on-Highway sources in Canada* (SENES Consultants and Air Improvement Resources, 2002). MOBILE6.2C input files have been generated to account for the following standards and regulations for fuels:

i) Implementation of a maximum sulphur content of 80 ppm with an average of 30 ppm for on-road gasoline beginning in 2005;

ii) Implementation of a maximum sulphur content of 500 ppm for on-road diesel fuel phasing in from 1995-1998 (low sulphur diesel);
iii) Implementation of a maximum sulphur content of 15 ppm for on-road diesel fuel beginning in 2006 (ultra-low sulphur diesel).

In consultation with experts, the low-sulphur gasoline was actually modeled at 25 ppm, and ultra-low sulphur diesel was actually modeled at 10 ppm.

A speed profile was developed for each province and territory, and used as input to the MOBILE6.2C model. Detailed information on the generation of speed profiles is found in the report *Average speed estimates for Mobile6C emissions forecasting* (Delcan Corporation and iTRANS Consulting Inc., 2003)

4.1.4   Activity Level

The actual activity level is vehicle kilometres traveled (VKT). To arrive at estimates of VKT, the vehicle fleet must be understood. Specifically, the data needed includes the number of each class of vehicle, and how far each travels on an annual basis. Vehicle populations were applied to estimates of mileage accumulation by vehicle class to estimate vehicle kilometres traveled. Mileage accumulation rates were derived from odometer readings of vehicles passing through the Drive Clean I/M program more than once. Mileage accumulation rates are also used within MOBILE, and can be multiplied by vehicle populations (per class) to establish vehicle kilometres traveled (VKT). The generation of the mileage accumulation file used in MOBILE6.2C is described in the short summary document, *Mileage accumulation rate file used in MOBILE6.2C* (Environment Canada, 2005).

4.1.5   Comparison of 2006 Methods with Previous Methodology

The previous CAC Inventory released by Environment Canada was for calendar year 2005. In general, the methodology for the 2006 and 2005 Inventories are very similar. Revisions to the MOBILE6.2C model, revised vehicle population estimates for Ontario and British Columbia, the use of mileage accumulation rates from the DriveClean program, and credits from the DriveClean and AirCare programs, along with minor changes to certain fuel characteristics are noted as differences between the 2005 and 2006 CAC Inventories.

4.1.6   Alternative Methods Used by Provinces/Territories

The same methodology was applied to all provinces and territories.

4.1.7   References

Sulphur in Liquid Fuels, annual, Oil, Gas and Energy Branch, Environment Canada

Road Motor Vehicles: Registration, annual, Statistics Canada. **No. 53-219**

Fuel Consumption Survey: Passengers Cars, 1979-1988, Statistics Canada, Special Surveys Program. Publications Numbers **53-007** and **53-225**

Frequently Asked Questions on MOBILE6.2C, 2003, Environment Canada

Environment Canada's Proposed Plan for the Canadian Conversion of MOBILE6, 2002 Environment Canada

The development of the MOBILE6.2C model, 2005, Environment Canada

Users' Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model, EPA document EPA420-R-02-028, 2002, United States Environmental Protection Agency

Technical Guidance on the Use of MOBILE6 for Emission Inventory Preparation, 2002, United States Environmental Protection Agency

Emissions of Air Toxics from on-Highway sources in Canada, 2002, SENES Consultants and Air Improvement Resources

Average Speed Estimates for MOBILE6C Emissions Forecasting, 2003, Delcan Corporation and iTRANS Consulting Inc

Updated Estimate of Canadian On-Road Vehicle Emissions for the Years 1995-2020, (revised October 2002), SENES Consultants and Air Improvement Resources

Canada's Energy Outlook: The Reference Case 2006, 2006, Natural Resources Canada

2004 Rates Schedule, Rate Class & Territory, 2003, Insurance Corporation of British Columbia

Motorcycle & All-Terrain Vehicle Annual Industry Statistics Report, 2003, Motorcycle and Moped Industry Council.

Comprehensive Energy Use Database, 2005, Natural Resources Canada/Office of Energy Efficiency

Vehicle Fleet Profiles for Ontario and British Columbia, 2004, Stewart-Brown Associates

Mileage accumulation rate file used in MOBILE6.2C, 2005, Environment Canada

Report on Energy Supply-Demand in Canada, annual, Statistics Canada (**57-003**)

4.1.8   Guidebook Sector Documentation Record

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TRANSPORTATION SECTOR

4.2   OFF-ROAD VEHICLES AND ENGINES

4.2.1   General Description

This sub-sector covers CAC emissions from engines, vehicles and machines (collectively called 'applications') not licensed for use on-road. Off-road applications include small spark-ignition engines such as lawnmowers and chainsaws; large spark-ignition engines such as those in forklifts; recreational vehicles and engines such as outboard engines, personal watercraft, snowmobiles and off-highway motorcycles; and off-road diesel engines such as those used in agricultural and construction equipment. While these machines may have various sources of power, only internal combustion engines are considered. For Environment Canada's 2006 CAC Inventory, estimates were made for all engines using gasoline, compressed natural gas (CNG), liquefied petroleum gas (LPG) and diesel fuel. Emission estimates were generated on a provincial/territorial level, then summed to get Canadian national level estimates. In the case of British Columbia and Ontario, estimates were generated at a greater level of detail, sub-dividing Ontario into four Phases, and British Columbia into three Phases, to align with the partitions used in on-road estimates.

4.2.2   Sector Description

The off-road sector includes the following categories of vehicles and equipment:

- recreational equipment/vehicles, such as all-terrain vehicles and off-road motorcycles;
- logging equipment, such as chainsaws;
- agricultural equipment, such as tractors;
- construction and mining equipment, such as graders and backhoes;
- industrial equipment, such as forklifts and sweepers;
- residential/commercial lawn and garden equipment, such as leaf blowers and snowblowers;
- recreational marine vessels, such as personal watercraft;
- airport ground support equipment; and
- railway maintenance equipment.

Other mobile sources of emissions include on-road, air, rail and commercial marine transportation. None of these sources is considered to be off-road except for equipment used for loading activities of these transportation modes, such as forklifts, cranes and container handling machines.

4.2.3   Inventory Method

Emission estimates from off-road applications were generated using a bottom-up approach; developing emissions factors and applying them to activity levels. Generally,

emission factors were developed using NONROAD2004(draft) and the activity level was the number of applications and hours of use.

Emissions factors for fine particulate matter (PM10 and PM2.5); sulphur oxides (SOx); oxides of nitrogen (NOx); volatile organic compounds (VOCs); carbon monoxide (CO); and ammonia (NH3) were estimated using the NONROAD2004(draft) model from the U.S. EPA, with Canadian input data. Total particulate matter (TPM) was estimated from NONROAD's PM10 estimate, using the EPA's *PM Calculator* tool. The NONROAD model estimates emissions for all off-road application categories. The model includes more than 80 basic and 260 specific types of off-road applications, and further stratifies application types by horsepower rating and fuel type (i.e., gasoline, diesel, compressed natural gas, and liquefied petroleum gas). Further information on the Canadian adaptation of the NONROAD model can be found in the report *User's Guide for the Canadian Adaptation of the U.S. EPA NONROAD Emissions Inventory Model* (Roland Vaivads, 2004). Input files were created for NONROAD2004(draft) to account for the emission impacts of the different implementation time frames of applicable emission standards, the meteorological conditions, and the fuel characteristics in Canada.

Meteorological data comes from Meteorological Services Canada. For each province/territory/region, the largest city by population is selected. For each of these cities, the largest airport (international if possible) is selected as the station from which to draw meteorological data. Airports are used because there is one in each city, and because they often contain the most complete and longest-running datasets. The meteorological data for the city is assigned to the entire province/territory/region, as is done for on-road emission estimates. The meteorological stations used in Environment Canada's 2006 CAC Inventory are listed in **Appendix D** of this report. Annual maximum and minimum temperatures are integrated into the input files. Diesel and gasoline sulphur levels, in parts per million (ppm), were based on the report *Sulphur in Liquid Fuels* (Environment Canada's Oil, Gas and Energy Branch, annual). All other fuel characteristics, such as Reid Vapour Pressure (RVP) and oxygenates, were obtained from the report *Emissions of Air Toxics from on-Highway sources in Canada* (SENES Consultants and Air Improvement Resources, 2002). All fuel characteristics agree with those used for on-road estimates, where applicable. For this reason, there is some repetition of the information listed in **Section 3.3c**. NONROAD input files have been generated to account for the following standards and regulations for fuels:

i) Implementation of a maximum sulphur content of 80 ppm with an average of 30 ppm for on-road gasoline beginning in 2005;
ii) Implementation of a maximum sulphur content of 500 ppm for on-road diesel fuel phasing in from 1995-1998 (low sulphur diesel);
iii) Implementation of a maximum sulphur content of 15 ppm for on-road diesel fuel beginning in 2006 (ultra-low sulphur diesel).
iv) Implementation of a maximum sulphur content of 500 ppm for off-road, rail and marine diesel fuel beginning in 2007 (low sulphur diesel).
v) Implementation of a maximum sulphur content of 15 ppm for off-road diesel fuel beginning in 2010 (ultra-low sulphur diesel).

In consultation with experts, the low-sulphur gasoline was actually modeled at 25 ppm, and ultra-low sulphur diesel was actually modeled at 10 ppm.

4.2.4   Activity Level

The main activity levels used for this sub-sector are the number of off-road vehicles/engines in each province/territory and the average hours of use of each type of equipment. Because of the level of detail available from NONROAD, it is not reasonable to list all vehicle/engine counts or hours of use in this summary. Instead, readers are referred to the report *Environment Canada's Estimates of Off-Road Engine Populations for the NONROAD model* (ChemInfo Services, 2004). The report lists all engine/vehicle counts, hours of use and all sources of data and assumptions made in the estimation and allocation of the data.

An addition to the 2006 CAC Inventory is an estimate of off-road diesel equipment in operation in the Oil Sands projects of Alberta. Respecting two reports from Clearstone (Clearstone Engineering 2003 and 2005), emissions were given per facility. Just the mobile sources were extracted, and only the 'Mobile mine fleet' was considered off-road. In parallel, NONROAD was run based on data from the Environmental Impact Assessments (EIA) submitted by certain facilities. The EIA data allowed for equipment profiles to be generated by facility, and for NONROAD input files to be created. The results for the profiles and the NONROAD run were to create pollutant-specific growth rates, by vehicle/engine type that could disaggregate the Clearstone data and provide forecasts.

4.2.5   Comparison of 2006 Methods with Previous Methodology

The previous CAC Inventory released by Environment Canada was for calendar year 2005. In general, the methodology for the 2005 and 2006 Inventories are very similar. For the 2006 CAC Inventory, an estimate of diesel mobile equipment in use in the Oil Sands of Alberta has been integrated.

4.2.6   Alternative Methods Used by Provinces/Territories

The same methodology was applied to all provinces and territories.

4.2.7   References

Sulphur in Liquid Fuels, annual, Oil, Gas and Energy Branch, Environment Canada

Emissions of Air Toxics from on-Highway sources in Canada, 2002, SENES Consultants and Air Improvement Resources

User's Guide for the Canadian Adaptation of the U.S. EPA NONROAD Emissions Inventory Model, 2004, Vaivads, R.H. for Environment Canada

Environment Canada's Estimates of Off-Road Engine Populations for the NONROAD model, 2004, ChemInfo Services for Environment Canada

User's Guide for the EPA Nonroad Emissions Model Draft NONROAD 2002, December 2002, United States Environmental Protection Agency

Fuel Consumption of Off-Road Engines, 2004, Vaivads, R.H, and Jonker, R

4.2.8   Guidebook Sector Documentation Record

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TRANSPORTATION SECTOR

4.3 AVIATION

4.3.1 General Description

This sub-sector covers CAC emissions from aircraft, but not airport support equipment (captured under off-road applications). Jets, turbo-props, helicopters and military aircraft are assumed to use turbo aviation fuel, piston aircraft are assumed to use aviation gasoline. Emissions from aircraft are further stratified into components of landing/take-off (LTO) and cruise (in-flight). An LTO is a complete landing/take-off cycle and includes idle, taxi, climb-out and decent/approach. The cruise component is all flight above 3000 feet (914 metres). Typically, only emissions from the LTO are inventoried as contributing to ground-level ozone formation..

Emissions from airport activity that is not from aircraft (such as aircraft maintenance vehicles and equipment) are not covered in this sector. Airport support engines and vehicles are covered under off-road vehicles and engines, section 4.2 of this guide.

4.3.2 Sector Description

For the smaller aircraft, the basic element in the piston engine is the combustion chamber or cylinder, where mixtures of fuel and air are burned and from which energy is extracted by a piston and crank mechanism, thus driving the propeller. A majority of aircraft piston engines have two or more cylinders and are generally classified according to their cylinder arrangement — either "opposed" or "radial." Opposed engines are installed in most light or utility aircraft, whereas radial engines are used mainly in large transport aircraft. Almost no single row in-line or V-engines are used in current aircraft (U.S. EPA 1985).

The gas turbine engine on larger planes usually consists of a compressor, a combustion chamber and a turbine. Air entering the forward end of the engine is compressed and then heated by burning fuel in the combustion chamber. The major portion of the energy in the heated air stream is used for aircraft propulsion. Part of the energy is expended in driving the turbine, which in turn drives the compressor. Turbofan and turboprop (or turboshaft) engines use energy from the turbine for propulsion, and turbojet engines use only the expanding exhaust stream for propulsion (U.S. EPA 1985).

4.3.3 Inventory Method

Emission estimates from aircraft were generated using a bottom-up approach; obtaining emissions factors and applying them to activity level data. Generally, emission factors were taken from current models and the activity data were the number of aircraft movements (landings and take-offs).

No single source provided LTO and cruise emission factors for all pollutants, for aircraft using turbo aviation fuel and aviation gasoline.

4.3.3a NOx, VOC, SOx and CO for aircraft using turbo aviation fuel during cruise
The U.S. Federal Aviation Administration (FAA) developed a model called SAGE (System for Assessing Aviation's Global Emissions). The FAA used SAGE (version1.5) for an inventory, and published the results in the report *Global Aviation Emissions Inventories for 2000 through 2004* (FAA, 2005). Emission factors, per unit of fuel used, for NOx, CO and HC (converted to VOC) were drawn from this report for aircraft at cruise. SOx emission rate was derived by taking the amount of SOx emitted, and dividing by the amount of fuel used.

4.3.3b NOx, VOC, SOx and CO for aircraft using turbo aviation fuel during LTO
The Inter-Governmental Panel on Climate Change (IPCC) provides guidance on the estimation of pollutants. The most current IPCC guidelines use information from SAGE, the Engine Exhaust Emissions Data Bank (2004) from International Civil Aviation Organization (ICAO) and the U.S. Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) to generate a set of emission factors and fuel consumption during LTO.

4.3.3c PM for aircraft using turbo aviation fuel
By far the least understood and most complex pollutant to estimate from aircraft is PM. AERO2k is a European model that estimates emissions from aircraft. The report *AERO2k Global Aviation Emissions Inventories for 2002 and 2025* (QinetiQ Ltd., 2004) provides an estimate of the non-volatile component of PM, per unit of fuel used. The thesis paper *Aircraft Particulate Matter Emission Estimation through all Phases of Flight* (EUROCONTROL Experimental Centre, 2005) provides a first-order approximation of the volatile component of PM. So the first-order multiplier was applied to AERO2k's 'soot' emission factor to provide a complete PM emission factor, per unit of fuel used. Aligned with EPA's guidance TPM is equivalent to PM10, while PM2.5 is .976 of PM10. While it is reasonable to believe that rich operations at LTO would lead to less efficient combustion and more PM, there is nothing to defensibly quantify the difference. As such, the PM emission factor per unit of fuel used is applied uniformly throughout all components of flight (LTO and cruise).

4.3.3d NOx, VOC, and CO for aircraft using aviation gasoline during cruise and LTO
The Swiss Federal Office of Civil Aviation (FOCA) is the only source of emission test data for aircraft using aviation gasoline (piston aircraft). The report *Data base for aircraft piston engine emission factors* (FOCA, 2006) summarizes the test data. The actual test data was accessed and used to generate emission factors and fuel use during LTO.

4.3.3e SOx and PM for aircraft using aviation gasoline during cruise and LTO

The FOCA dataset did not include estimates for SOx or PM. As such, the generic emission factors for "General Aviation" were drawn from the EPA emission factor database. The EPA emission factors are in unit per LTO, so they were divided by fuel use per LTO to yield emission factor per unit of fuel used. The factors were then applied uniformly throughout all components of flight (LTO and cruise) based on fuel use.

4.3.4   Activity Level

Data on movements per airport are published at an aggregated level in *Aircraft Movement Statistics* (Transport Canada, annual). A 'movement' is a landing or a take-off, so movements in must be halved to determine complete LTO cycles, the actual activity level needed. For the years 1996-2002, a detail extraction from the Aircraft Movement Statistics (AMS) database was provided to Environment Canada. The detailed information allowed for the mapping of movements to specific aircraft types, using the maximum take-off weight. Specific aircraft types could then be allocated to the SAGE and FOCA classes, and have emission factors assigned. For certain local flights, less information is available (no maximum take-off weight) and the method to allocate to SAGE and FOCA classes wasn't as robust. All local/civilian/jets were assigned to the low-thrust jet class from SAGE. All local/civilian/multi and 'unspecified' were assigned to the smallest turboprop class. All local/civilian/singles were assigned to the average FOCA class.
The totals of the detailed extraction aligned well with the published, aggregated totals.

4.3.5   Comparison of 2006 Methods with Previous Methodology

New emission factors (from recent models) were used in the 2006 CAC emissions Inventory.

4.3.6   Alternative Methods Used by Provinces/Territories

The same methodology was applied to all provinces and territories.

4.3.7   References

Canadian Emissions Inventory of Criteria Air Contaminants, 1996, Environment Canada, Report EPS 5/AP/7E

FAA Aircraft Engine Emissions Database User's Manual, Federal Aviation Administration, **Version 2.1**, U.S. Department of Transportation, Washington

Potential Environmental Impacts Related to Proposed Runway Expansion at Toronto's International Airport, 1993, Patterson, J.G. and B.G. Woodmansey, *Energy Sources*, **volume 15**, pp. 675-719

A Nationwide Inventory of Anthropogenic Sources and Emissions of Primary Fine Particulate Matter, 1981, SNC/GECO Inc. and Ontario Research Foundation prepared for Environment Canada

Air Quality Modeling Volume 1: L.B. Pearson International Airport Airside Development Project, Aviation in Southern Ontario: A strategy for the Future, April 1991, Transport Canada, Final Report **no.21,** TP10853E

Aircraft Movement Statistics, annual, Transport Canada (**TP577**)

Civil Aircraft Activity in Canada, Transport Canada, (**TP2468**)

Review of Sulphur Content of Petroleum and Synthetic Fuels 1978-1989, October 1988, RTM Engineering Ltd.

Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources. Fourth Edition, 1985, U.S. Environmental Protection, **Report No. AP-42**, Office of Mobile Sources, Ann Arbor, Michigan

Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, Revised, 1989, U.S. Environmental Protection Agency, EPA-450/4-81-026d (revised), Office of Mobile Sources, Ann Arbor, Michigan

New methodology for Modeling Annual Aircraft Emissions at Airports, 1994, Woodmansey, B.G. and J.G. Patterson, *Journal of Transportation Engineering*, **Vol. 120, no 3**

Report on Energy Supply-Demand in Canada, annual, Statistics Canada (**57-003**)

Canada's Energy Outlook: The Reference Case 2006, 2006, Natural Resources Canada

4.3.8   Guidebook Sector Documentation Record

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TRANSPORTATION SECTOR

4.4 COMMERCIAL MARINE

4.4.1 General Description

This sub-sector covers CAC emissions from ocean-going and non-ocean-going commercial marine vessels and military (Navy) vessels, but not land-based port support equipment, loading/unloading equipment or recreational marine engines (captured under off-road applications). The sub-sector is an aggregation of a number of classes of vessels that encompass freighters, tankers, tugs, ferries, passenger boats (inboard), fishing boats, and container ships. In 2004, Environment Canada initiated a study of emission estimation methodology, including a review of methods currently used by Environment Canada. The report *Review of Methods Used in Calculating Marine Vessel Emission Inventories* (SENES Consultants Limited, 2004) is a comprehensive look at this sub-sector. Recommendations from this report were embraced in this methodology.

4.4.2 Sector Description

Commercial vessel sizes range from 20-foot charter boats to the largest tankers and military vessels. Diesel engines or steam turbines power the majority of vessels in this category. These are commonly called motor ships (diesel) and steamships. The predominant fuel for both types is oil, both distillate and residual grades. Steamships and very large diesel engines are fuelled with the heavier oils, whereas lighter diesel engines require distillate oil, although some residual may be added.

4.4.3 Inventory Method

Emission estimates from commercial marine vessels were generated using a bottom-up approach; using emissions factors and applying them to activity level data. Generally, emission factors were taken from current studies and the activity data were the number of ship movements by engine size and fuel type.

No single source provided all emission factors for ocean-going and non-ocean-going, heavy fuel-oil and marine diesel powered vessels.

4.4.3a PM, NOx, VOC, CO and NH3 for ocean-going vessels
Three specific studies have been drawn from to establish emissions and emission factors for ocean-going vessels (OGVs). A report for the West Coast *2005-2006 BC Ocean-Going Vessel Emissions Inventory* (British Columbia Chamber of Shipping, 2007), one for the East Coast and Great Lakes *Marine Emission Inventory Study Eastern Canada and Great Lakes* (Levelton Consultants Ltd., 2006) and a study completed for North America *Estimation, Validation and forecasts of Regional Commercial Marine Vessel* (Corbett, 2006) were used in concert to generate a comprehensive Canadian Inventory for ocean-going commercial marine vessels. To account for Canada's 200 nautical mile limit,

the 'underway' component of the Chamber of Shipping's report was replaced by that from Corbett (the scope of Chamber's report was 50nm). The non-underway components of the Chamber's reports were respected. All reports are based on similar methodologies, aligned with those in the SENES report. Using that report as a basis, a computer model (known as a Tool) was created to generate emissions. The reports listed above are aligned with the results from the Tool. Updates to the Tool made after these reports will yield slightly different results. Specifically, updates to the Tool (not reflected in the reports) include: load factors being re-assessed/changed; inclusion of "reduced speed zones" where vessels run at lower loads; updating of certain emission factors; adoption of region-specific growth factors based on economic cargo growth from Transport Canada; and updating of sulphur contents to better reflect foreign and domestic fuels (higher sulphur for the foreign fuels, lower for domestic).

4.4.3b SOx for ocean-going vessels
Emission factors for SOx emissions are determined based on several components. The key defining component for determining SOx emission factors, and ultimately emissions, is the sulphur content of the fuel burned by the marine vessels. Other defining components for determining SOx emission factors are:
- Vessel type
- Mode vessel is travelling in
- Engine speed
- Engine type (main or auxiliary)
- Engine load
- Type of fuel burned

SOx emission factors on the West Coast of Canada were determined for each vessel's movements. This was done using survey information provided by the vessels when they were at a Western port. If no information for a certain vessel was provided, default values and therefore default emission factors were used based on all the survey data collected for specific vessel types.

4.4.3c PM, NOx, VOC and CO for non-ocean-going vessels
Lloyd's data is summarized in the report *Commercial Marine Emissions Inventory for EPA Category 2 and 3 Compression Ignition Marine Engines in the United States Continental and Inland Waterways* (EPA, 1998). Specifically, Table 4 of this report gives emission factors for CO, PM, NOx and HC (converted to VOC) per unit of fuel used. A single set of emission factors is then applied to the amount of fuel available. From the Lloyds' data, there is no distinction between emission factors and fuel type, so the emission factors can be applied to marine diesel and heavy fuel-oil (HFO). The ratio of TPM to PM10 to PM2.5 (1:1:0.92) is aligned with that used by EPA.

4.4.3d SOx for non-ocean-vessels
Emission factors for SOx are dependant on the sulphur level in the fuel found in the report *Sulphur in Liquid Fuels* (Environment Canada's Oil, Gas and Energy Branch, annual). The SOx emission factor is given by the following relationship: SOx emission factor (per fuel use) = $20 \times (S\%)$, where S% is the percent of sulphur contained in the

fuel. The relationship was drawn from the report *Marine Exhaust Emissions Research Programme* (Lloyd's Register Engineering Services, 1995).

4.4.3e NH3 for non-ocean-vessels
Limited information was available on which to base emission factors for NH3. A single study *Review of Current Methodologies for Estimating Ammonia Emissions* (Coe et. al., 1996) yielded an emission factor per unit of fuel used.

4.4.3f Other pollutants for commercial marine vessels
Using EPA's databases for hazardous air pollutant, stable ratios to VOC were established for all PAHs, lead and cadmium. Cadmium was only applicable to commercial marine vessels using heavy fuel-oil. A similar strategy was applied to derive emission factors for benzene and ethyl benzene. The ratios were drawn from the report *Documentation for aircraft, commercial marine vessel, locomotive, and other nonroad components of the National Emissions Inventory* (EPA, 2005).

4.4.3g Emission standards
NOx emissions in this inventory respect the International Maritime Organization (IMO) NOx Tier I emissions standards. These standards came into effect in 2000. As new, post-2000 ships replace older pre-2000 ships, NOx emissions are reduced because the newer ships comply with the more stringent standard.

4.4.4   Activity Level

Data on ocean-going vessels sailing in the East Coast/Great Lakes/St. Lawrence region is embedded in the Tool and is drawn from Lloyd's Marine Intelligence Unit (LMIU) and INNAV (Canadian Coast Guard Information System on Marine Navigation). Emissions are forecasted using economic cargo growth rates for the region. These growth rates were developed using predicted tonnage of specific commodities carried by vessels in the region. This information was provided to Environment Canada by Transport Canada.
Data on ocean-going vessels sailing in the West Coast of Canada draws upon LMIU and the Vessel Traffic Operations and Support Systems (VTOSS) from Department of Fisheries and Oceans. Using the same methodology as in the Corbett study (Corbett, 2006), total vessel power trends were investigated. It has been determined by Dr. Corbett et. al. that vessel power is a representative indicator of emissions forecast. Using 10 years' worth of LMIU data, a growth trend was applied to establish a fleet-wide cumulative average growth rate (CAGR).
Cross-referencing vessels characteristics from Lloyd's with the movement statistics from the other sources allows for accurate data on vessel type and power ranges, along with spatial and temporal allocation.

For non-ocean-going vessels, emission factors are based on amount of fuel used. As such, the activity level is the amount of fuel. Totals for heavy-fuel oil and marine diesel available per province/territory are published in the *Report on Energy Supply-Demand* (Statistics Canada, annual). From the report *Gaseous Emissions from Ships* (Environment

Canada, 1995), fuel consumption was given per vessel type. This profile of fuel use was held constant and applied to the fuel available from the *Report on Energy Supply-Demand* (Statistics Canada, annual). Growth rates also drew upon ship movement data, as published in *Shipping in Canada* (Statistics Canada, annual), which provided ship movements (international and domestic) for years 1985-2005.

4.4.5   Comparison of 2000 Methods with Previous Methodology

There were no changes in methodology from the 2000 inventory for this sector.

4.4.6   Alternative Methods Used by Provinces/Territories

The 2006 CAC Inventory represents an entirely new methodology for the estimation of emissions from commercial marine vessels.

4.4.7   References

Sulphur in Liquid Fuels, annual, Oil, Gas and Energy Branch, Environment Canada

Report on Energy Supply-Demand in Canada, annual, Statistics Canada (**57-003**)

Shipping in Canada, annual, Statistics Canada (**54-205**)

Canadian Emissions Inventory of Criteria Air Contaminants, 1996, Environment Canada, Report EPS 5/AP/7E

Gaseous Emissions from Ships, 1995, Environment Canada, MSED Report # 95-05, prepared by Polar Design Associates Ltd.

1993 Marine Vessel Air Emissions Inventory for the Lower Fraser Valley, November 1995, Levelton Associates, prepared for Environment Canada, BC Ministry of Environment, Lands and Parks, and Greater Vancouver Regional District by B. H. Levelton & Associates Ltd., Richmond, BC, file 494-664.

Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources. Fourth Edition, 1985, U.S. Environmental Protection, **Report No. AP-42**, Office of Mobile Sources, Ann Arbor, Michigan

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Canada's Energy Outlook: The Reference Case 2006, 2006, Natural Resources Canada

2005-2006 BC Ocean-Going Vessel Emissions Inventory, 2007, British Columbia Chamber of Shipping

Marine Emission Inventory Study Eastern Canada and Great Lakes, 2006, Levelton Consultants Ltd.

Estimation, Validation and forecasts of Regional Commercial Marine Vessel, 2006, Dr. J. Corbett

Quantification of emissions from ships associated with ship movements between ports in the European Community, 2002, Entec UK Ltd.

4.4.8   Guidebook Sector Documentation Record

Release Version: 1

Date: April 2008

Author: Brett Taylor, Pollution Data Division

TRANSPORTATION SECTOR

4.5 LOCOMOTIVES

4.5.1 General Description

This sub-sector covers CAC emissions from locomotives, but not rail support equipment (captured under off-road applications). Locomotive emissions were obtained the report *Locomotive Emissions Monitoring Program 2004* (Environment Canada, 2005).

4.5.2 Sector Description

Diesel-electric locomotives are used either in rail yard switching or in road-haul service. Locomotives can be further classified on the basis of engine configuration:

Switch locomotives:	2-stroke (supercharged)
	4-stroke
Road service locomotives:	2-stroke (supercharged)
	2-stroke (turbocharged)
	4-stroke

Emissions from rail activity that is not from locomotives (such as railway maintenance vehicles and equipment) are not covered in this sector. Railway maintenance engines and vehicles are covered under off-road vehicles and engines (section 4.2).

4.5.3 Inventory Method

In 1995 the Railway Association of Canada's (RAC) signed a Memorandum of Understanding (MOU) on locomotive emissions with Environment Canada for the period 1990–2005. Under the terms of the MOU, the RAC provides national level, annual traffic volumes and diesel fuel consumption for mainline, branchline, yard switching, and passenger service. For Environment Canada's 2006 CAC Inventory, locomotive emissions, at the Canadian national level, were obtained the report *Locomotive Emissions Monitoring Program 2004* (Environment Canada, 2005). To get provincial/territorial level emissions, *Rail in Canada* (Statistics Canada, annual) were used. *Rail in Canada* (Statistics Canada, annual) provides provincial/territorial level diesel fuel consumption information for rail (Table 3.4 until the 1999 publication when it became Table 7). The provincial/territorial level fuel consumption ratios were applied to the national level emissions total in *Locomotive Emissions Monitoring Program 2004* (Environment Canada, 2005), assuming that fuel consumption and pollutant emissions follow the same trend.

For Environment Canada's 2006 CAC Inventory, emission estimates were taken directly from *Locomotive Emissions Monitoring Program 2004* (Environment Canada, 2005). For trend data, other *Locomotive Emissions Monitoring Program* reports were used.

For Environment Canada's 2006 CAC Inventory, emission estimates taken from the report *Locomotive Emissions Monitoring Program 2004* (Environment Canada, 2005) account for the following fuel regulations;

i) Implementation of a maximum sulphur content of 500 ppm for rail diesel fuel beginning in 2007 (low sulphur diesel).
ii) Implementation of a maximum sulphur content of 15 ppm for rail diesel fuel beginning in 2012 (ultra-low sulphur diesel).

4.5.4   Activity Level

For Environment Canada's 2006 CAC Inventory, emission estimates were taken directly from *Locomotive Emissions Monitoring Program 2004* (Environment Canada, 2005). For trend data, other *Locomotive Emissions Monitoring Program* reports were used.

4.5.5   Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 2005 inventory for this sector

4.5.6   Alternative Methods Used by Provinces/Territories

The same methodology was applied to all provinces and territories.

4.5.7   References

Rail in Canada, annual, Statistics Canada (**52-216**)

Report on Energy Supply-Demand in Canada, annual, Statistics Canada (**57-003**)

Locomotive Emissions Monitoring Report 2004, 2005, Transportation Systems Division, Environment Canada

Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1989, U.S. Environmental Protection Agency, EPA-450/4-81-026d (revised), Office of Mobile Sources, Ann Arbor, Michigan.

Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources. Fourth Edition, 1985, U.S. Environmental Protection, **Report No. AP-42**, Office of Mobile Sources, Ann Arbor, Michigan

Recommended Reporting Requirements for Locomotive Emissions Monitoring; A Background Report, September 1994, EPS2/TS/8

Locomotive Emissions Monitoring Report 1998, 2000, Transportation Systems Division, Environment Canada

Recommended improvements to the CMU ammonia emission inventory model for use by LADCO, 2003, Sonoma Technology, Inc.

4.5.9   Guidebook Sector Documentation Record

Release Version: 1

Date: April 2008

Author: Brett Taylor, Pollution Data Division

CHAPTER 5
INCINERATION SECTOR

5.1 Cremation
5.2 Municipal, Industrial, Commercial and Institutional Incineration
5.3 Wood Waste Incineration

INCINERATION SECTOR

5.1   CREMATION

5.1.1   General Description

According to preliminary data and estimations provided by the Cremation Association of North America (CANA), Quebec had the highest percentage of deaths resulting in cremation in 2006, as well as the highest number of cremations, which were 83.0% and 44,633 bodies, respectively. British Columbia was the province that had the next highest rate of cremation with 79.3%; however, in absolute numbers Ontario had the second highest number of cremations.

5.1.2   Sector Description

Crematoria dispose of human cadavers by combustion using an auxiliary fuel, typically natural gas, to improve the combustion efficiency. Emissions result from the combustion of cadavers, the cardboard or wooden containers and the auxiliary fuel.

Emissions from crematoria include particulates (TPM, PM10 and PM2.5), sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs) and carbon monoxide (CO). In addition, trace quantities of heavy metals (Hg, Cd and Pb) and persistent organic pollutants can be emitted.

5.1.3   Inventory Method

Emissions from crematoria are inventoried as an area source by multiplying an emission factor with an activity level. Crematoria emission factors in kilograms per body cremated have been obtained from four sources and are given in Table 5.1-1 and Table 5.1-2 below.

Table 5.1-1: Crematoria Emission[1] Factors for Criteria Air Contaminants

Pollutant	Emission factors (kg/body)
TPM	0.03856[2]
PM10	0.03856[2]
PM2.5	0.03856[2]
SO_x	0.0544[2]
NO_x	0.3085[2]
VOCs	0.0130[3]
CO	0.1406[2]

TABLE 5.1-2: Crematoria Emission[1] Factors for Toxics

Pollutant	Emission factors (kg/body)
Hg	1.4923E-03[2]
Cd	5.0349E-06[2]
Pb	3.0028E-05[2]
D/F	17[4]
B(a)p	1.3200E-08[2]
B(b)f	7.2121E-09[2]
B(b)k	6.4410E-09[2]
I(1,2,3-cd)p	6.9853E-09[2]

Notes:
1. Emission factors include the combustion of a cardboard and wood container and the associated fuel combustion. Body weights range from 58 to 74 kg.
2. Emission factors obtained from the U.S. EPA's FIRE versions 5.1, 5.2, 6.25 emission factor retrieval databases.
3. Cremation Association of North America (1993).
4. EPA (2000) ug I-TEQ/body.

5.1.4   Activity Levels

The activity levels used to estimate the 2006 cremation emissions were the number of cremations by province, obtained from CANA (CANA 2008). At the time the data was provided, four of the twelve values were considered preliminary. In addition, the number of cremations that occurred in the Northwest Territories was not available.

To approximate the percentage of deaths resulting in cremation for the Northwest Territories, the number of deaths in 2005 and 2006 (Statistics Canada 2008) and the percentage of deaths resulting in cremation for 2005 (CANA 2007) were used, since these were the most recent values available for the region. This method assumed that the ratio of the percentage of cremated deaths to the number of deaths in 2005 and 2006 were equal. The resulting percentage of cremated deaths was applied to the number of deaths in the territory for 2006. Table 5.1-3, below, provides the 2006 provincial/territorial numbers of cremations.

Table 5.1-3: 2006 Cremation Statistics

Province	Cremations (bodies)
Newfoundland and Labrador	884
Prince Edward Island	178
Nova Scotia	4,384
New Brunswick	2,539
Quebec	44,633
Ontario	44,335
Manitoba	5,427
Saskatchewan	4,386

Alberta	11,895
British Columbia	24,209
Yukon	99
Northwest Territories	35
Nunavut	2

5.1.5 Comparison of 2006 Methods with Previous Methodology

The 2005 and 2006 estimation methods differed greatly due to the availability of activity levels during inventory compilation. The 2005 number of cremations by province was estimated by applying the number of deaths to the rates of cremation. The number of deaths was determined by applying the ratio of 2004 deaths to 2004 population to the ratio of the unknown number of 2005 deaths over the 2005 population. In addition, the 2005 cremation rates were forecasted from 2004 data.

As noted in section 5.1.4, estimation of the number of cremations was not required for 2006 since CANA provided the number of cremations for all provinces/territories except the Northwest Territories.

5.1.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces for this sector.

5.1.7 References

Cremation Association of North America. 1993. Casket and Container Emission Study.

Cremation Association of North America. 2007. Final 2005 Statistics and Projections to the Year 2025 2006 Preliminary Data (www.cremationassociation.org/docs/CANA-Final06Prelim.pdf)

Cremation Association of North America. 2008. Email correspondence with Caitlin Geraghty (CGeraghty@smithbucklin.com). November 2008.

Statistics Canada. 2008. Annual Demographic Estimates. October to December 2007, Preliminary. Catalogue No. 91-002-X, Table 4.2.

U.S. EPA. 1996. FIRE (Factor Information Retrieval Data System) version 5.1, 5.2 and 6.25. Clearinghouse for Inventories & Emissions Factors, Technology Transfer Network, U.S. Environmental Protection Agency. (www.epa.gov/ttn/chief/software/fire/)

U.S. EPA. 2000. Draft Dioxin Reassessment. (http://cfpub.epa.gov/ncea/cfm/part1and2.cfm?ActType=default)

5.1.8 Guidebook Sector Documentation Record

Release Version: 2

Date: April 2009

Author: Susan Charles, Pollution Data Division

INCINERATION SECTOR

5.2 MUNICIPAL, INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL INCINERATION

5.2.1 General Description

Municipal governments in a few Canadian communities operate centralized municipal solid waste incinerators to combust refuse. They are primarily used in order to reduce waste volumes and recover energy.

Industrial, commercial and institutional solid waste incinerators are typically small-scale units of single or multiple chamber design for disposal of numerous types of refuse.

Emissions from this sector include TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs and CO, and also dioxins and furans and heavy metals.

5.2.2 Sector Description

Municipal solid waste incinerators of varying designs and configurations normally have burning capacities in excess of 50 t of refuse per day, and large units may incinerate up to 1000 t of waste per day (U.S. EPA 1989). All of the common gaseous and particulate pollutants are emitted during municipal solid waste combustion, with the extent depending on factors such as the composition of the refuse being burned, the type and operating conditions of the incinerator and the type and removal efficiencies of any installed control devices. The potential exists for significant particulate emissions due to the turbulence of combustion gases in contact with ash and condensation of metals after combustion. Intermediate products of incomplete combustion, such as CO, VOCs and other toxic chemicals, can also occur under improper operating conditions.

Industrial, commercial and institutional incinerator capacities vary widely, with feed rates normally ranging between 25 and 1800 kg of refuse per hour and an average capacity of approximately 100 kg/h (Energy and Environmental Analysis 1978; U.S. EPA 1985, Supplement C; Edwards and Cotton 1988). Modular units are used in various industries, commercial buildings, hotels, institutions and hospitals. They are typically batch fed, are operated intermittently, require auxiliary fuels and are usually operated without emission control devices (Environment Canada 1976; U.S. EPA 1985, Supplement C; MOE 1986). Smaller incinerators (e.g., single chamber) may be characterized by inefficient combustion with a tendency to emit products associated with incomplete combustion. Larger facilities may be controlled with afterburners or scrubbers.

5.2.3 Inventory Method

Emission factors based on tonnes of waste incinerated for municipal incineration were obtained from U.S. EPA AP-42 (U.S. EPA 1985, Supplement F, Section 2.1) and are given in Table 5.2-1.

Table 5.2-1: Municipal Solid Waste Incineration Emission Factors

Source	Emission factors (kg/t)							
	TPM[1]	PM_{10}	$PM_{2.5}$	SO_x	NO_x[2]	VOCs[3]	CO[2]	NH_3
Municipal waste incineration	0.1050	0.0200	0.0137	1.7300	1.6950	2.7890	0.2770	0.2000

Notes:
1. Emission factor for particulate matter assumes that 97% is controlled.
2. NO_x and CO emission factors are composites based on type of incinerator (80% waterfall, 15% rotary and 5% refractory).
3. VOC emission factors are estimated based on VOC emission factors for the industrial and commercial incineration sector.

Emission factors based on tonnes of waste incinerated for industrial, commercial and institutional incineration were derived from U.S. EPA AP-42 (U.S. EPA 1985, Supplement F, Sections 2.1 and 2.5) and are given in Table 5.2-2. For sewage sludge incineration, it was assumed that only particulate emissions are controlled. In deriving the emission factors for the multiple chamber and controlled air and other incineration, it has been assumed that all emissions are uncontrolled and that 95% of the waste was incinerated in a multiple chamber incinerator and 5% in a single chamber type incinerator.

Table 5.2-2: Industrial, Commercial and Institutional Incineration Emission Factors

Source	Emission factors (kg/t)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3
Sewage sludge incineration	0.5000	0.0500	0.0140	0.1500	0.0400	0.1000	0.0050	0.2000
Multiple chamber incineration	0.0350	0.0235	0.0189	1.2500	1.5000	0.8140	5.0000	0.2000
Controlled air and other incineration	0.0750	0.0555	0.0473	1.2500	1.0000	16.1680	10.0000	0.2000

Table 5.2-3: Industrial, Commercial and Institutional Incineration Heavy metals Emission factors

Fuel	Emission factors (units as specified)		
	Hg	Cd	Pb
Municipal waste incineration	0.09	0.0028	0.00545
Sewage sludge incineration	0.0016	0.0185	0.02

Multiple chamber incineration	2.8*10e-6	5.5*10e-6	0.000107
Controlled air and other incineration	2.8*10e-6	2.3*10e-7	1.41*10e-6

Sources: Fire 6.25
Municipal Waste Incineration SCC: 5-01-005-15
Sewage Sludge Incineration SCC: 5-01-001-02
Multiple Chamber SCC: 5-01-001-04, 07, 5-03-001-11, -15
Source: U.S. EPA AP-42 (1996) section 2.1, Table 2.1-1.
Controlled Air SCC: 5-01-001-01 -14
Source: U.S. EPA AP-42 (1996) section 2.1, Table 2.1-9.

Table 5.2-4: Dioxin and Furan Emission Factors for municipal and commercial incineration

Source	Emission factors (units as specified)
	I-TEQ Dioxin & Furan
Municipal Waste Incineration	38.2
Sewage Sludge Incineration	6.94

Source: Dioxins/Furan EPA Website
http://cfpub.epa.gov/ncea/cfm/part1and2.cfm?ActType=default

5.2.4   Activity Level

In 2006 pro-rated 2005 data was used due to lack in activity levels.

The amount of waste incinerated is calculated by multiplying the population by a waste generation rate, times a percentage that is incinerated.

The 2003 population statistics were obtained from Statistics Canada (2004). The waste generation rate was obtained from Dennis Jackson, Environment Canada. For Industrial, Commercial and Institutional Incineration, waste generation rates were not available for some provinces and the 1992 rates were used. (An Assessment of the Physical, Economic and Energy Dimensions of Solid Waste Management*", 1992)*

Table 5.2-5: Waste generation rate for Municipal and Industrial, Commercial and Institutional Incineration for 2002[1]

	2002	
Province/Territory	**kg/capita Mun.**	**kg/capita ICI**

Newfoundland and Labrador	445.42	Same as 2000 (taken from 1992)
Prince Edward Island	0.00	Same as 2000 (taken from 1992)
Nova Scotia	255.42	Same as 2000 (taken from 1992)
New Brunswick	341.50	288.51
Quebec[3]	466.31	429.37
Ontario	362.77	538.51
Manitoba	432.75	472.73
Saskatchewan	322.52	-
Alberta	372.37	527.50
British Columbia	329.08	469.84
Yukon	-	Same as 2000 (taken from 1992)
Northwest Territories and Nunavut	-	Same as 2000 (taken from 1992)

[1] Reference: Dennis Jackson, NOPP, Environment Canada. The 2002 numbers are also used for 2003.

Table 5.2-6: Percentage incinerated for Municipal and Industrial, Commercial and Institutional Incineration for landfilled and not landfilled [2]

Province/Territory	% Incinerated from landfills Mun	% Incinerated from landfill ICI	% Incinerated Mun	% Incinerated ICI
Newfoundland and Labrador	85.63	89.44	2.43	4.80
Prince Edward Island	46.31	78.59	8.76	18.52
Nova Scotia	86.13	82.32	5.64	6.14
New Brunswick	98.31	89.47	No incineration	No incineration
Quebec[3]	78.76	70.59	2.17	4.57
Ontario	80.37	38.15	0.66	1.39
Manitoba	98.92	82.73	No incineration	No incineration
Saskatchewan	94.98	80.05	No incineration	No incineration
Alberta	94.95	77.88	No incineration	No incineration
British Columbia	78.74	63.84	2.02	4.39
Yukon	No incineration	No incineration	No incineration	No incineration
Northwest Territories and Nunavut	No incineration	No incineration	No incineration	No incineration

[2] An Assessment of the Physical, Economic and Energy Dimensions of Solid Waste Management*", Environment Canada, 1992*

For sewage sludge, it was assumed that the amount incinerated was the same as that incinerated in 1995, i.e. 101.36kt for Québec, 113.98 kt for Ontario, and 0.15 kt for Saskatchewan.

Nunavut was assumed to have the same waste generation rates and incineration practices as those for the Northwest Territories and Yukon .

In 2003, municipal and industrial, commercial and institutional incineration did not occur in New Brunswick, Manitoba, Saskatchewan, Alberta, Yukon, the Northwest Territories or Nunavut.

5.2.5   Comparison of 2006 Methods with Previous Methodology

In 2006 pro-rated 2005 data was used due to lack in activity levels.

5.2.6   Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

5.2.7   References

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(www.epa.gov/ttn/chief/ap42/oldeditions.html)

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U.S. EPA. 1996. FIRE (Factor Information Retrieval Data System) version 5.1, 5.2 and 6.25. Clearinghouse for Inventories & Emissions Factors, Technology Transfer Network, U.S. Environmental Protection Agency. (www.epa.gov/ttn/chief/software/fire/)

Personal conversation : *Dennis Jackson Environment Canada National Office of Pollution Prevention (819) 953-6063.*

5.2.8   Guidebook Sector Documentation Record

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Date: March 2006

Author: Patrick Georges/ Pollution Data Division

INCINERATION SECTOR

This sector is included in WOOD INDUSTRIES and needs to be deleted

5.3   WOOD WASTE INCINERATION

5.3.1   General Description

Together, British Columbia and Ontario are responsible for over 60% of the wood waste incinerated in Canada, with British Columbia incinerating nearly twice as much as Ontario.
The provinces of Alberta and New Brunswick are responsible for just over 10% each of wood waste incinerated, with the remaining Atlantic and Prairie provinces making up the difference. The Northwest Territories, Nunavut, Yukon and Quebec have no wood waste incineration activity.

5.3.2   Sector Description

Wood waste incineration is associated with lumber, plywood and other forest product mills, typically employing conical burners (also referred to as wigwam or teepee burners). These are used in some remote areas to dispose of wood wastes such as sawdust, bark and other wood residues. Some of these wastes may be burned in boilers at sawmills to generate power. Alternatively, these wastes may be transported to nearby pulp and paper mills for use as pulp or fuel for combustion in boilers, where this is feasible. Although few measurements are available, significant emissions of all criteria pollutants are suspected. Emissions from the wood waste incineration sector include TPM, PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOCs, CO and NH_3, and also Heavy Metals (Mercury, Cadmium, Lead) , Dioxins and Furans and PolyAromatics Hydrocarbons (PAHs).

A wigwam burner is a truncated metal cone (with a screened top vent) in which the wood refuse is burned on a raised grate. Air is blown below the grate and above the fuel pile to maintain combustion of the wood refuse without supplementary fuel. Due to the generally poor combustion conditions (e.g., excessive air and low temperature) associated with often poorly maintained shells, such facilities are expected to represent significant sources of combustible pollutants such as smoke, CO and hydrocarbons (Environment Canada 1976; U.S. EPA 1985). The extent of pollutant control has not been recently documented, but most pollutants are presumed to be uncontrolled.

5.3.3   Inventory Method

Emissions from wood waste incineration are estimated using area source methods due to a lack of information on the use and quantities of wood waste burned.

For the area source estimations, emission factors are given in Table 5.3-1 and 5.3-2.

Table 5.3-1: Emission Factors for Wood Waste Incineration (CACs and NH3)

Source	Emission factors (kg/t)							
	TPM[1]	PM$_{10}$	PM$_{2.5}$	SO$_x$[2]	NO$_x$	VOCs	CO	NH$_3$
Wood waste incineration	2.9010	1.5956	1.1604	0.0500	0.5000	5.5000	65.0000	0.1260

Ref: U.S. EPA (1985)

Notes:

1. The emission factor for particulate matter is based on the assumption that 20% of the burners operate under satisfactory conditions, 45% operate under unsatisfactory conditions and 35% operate under very unsatisfactory conditions. In addition, 45% particulate control is assumed.
2. The emission factor for SO$_x$ is obtained from U.S. EPA (1985, Section 2.3).

Table 5.3-2: Emission Factors for Wood Waste Incineration (Heavy metals, Dioxins and Furans, PAHs)

Source	Emission factors (kg/t) except for D/F							
	Hg[1]	Cd[1]	Pb[1]	I Teq[2]	B(a)p[3]	B(b)f[3]	B(k)f[3]	I(cd)p[3]
Wood waste incineration	3.25*10e-4	8.5*10e-6	2.225*10e-4	0.56 ng I-TEQ/kg wood	9.5*10e-8	1*10e-4	3.6*10e-5	1.7*10e-7

References:

1. Hg, Cd, Pb FIRE 6.25
SCC: 1-01-009-01, -02, -03; 1-02-009-01,-02,-03, -06, -07; 1-03-009-01, -02, -03
2. dioxins and furans: EPA Report on website
http://cfpub.epa.gov/ncea/cfm/part1and2.cfm?ActType=default

3. PAH: B(a)p Fire 6.25, SCC 10100903, woodfired boiler wet wood uncontrolled
   PAH: B(b) f, Fire 6.25, SCC 10100903, wood fired boiler wet wood uncontrolled
 PAH: B(k) f, wood fired boiler wet wood uncontrolled.
 PAH: I(cd) P: FIRE 6.25, SCC 101000903, Wood/bark waste, wood fired boiler, wet wood uncontrolled.

5.3.4   Activity Level

The activity level for this sector is the quantity of wood waste incinerated in 2003 by each province. These values were approximated using a fixed percentage of the total solid waste quantities produced by pulp and paper mills and sawmills. Total solid wood waste quantities were obtained from Table 20 of Statistics Canada Catalogue No. 57-003-XIB. The percentage of wood waste incinerated is assumed to be 15% in 2003, consistent with the 1995 inventory. No wood waste incineration was assumed for Quebec.

5.3.5   Comparison of 2006 Methods with Previous Methodology

2005 data was used in 2006 due to lack in activity levels

5.3.6   Alternative Methods Used by Provinces/Territories

Alberta has reported emissions for teepee burners under its point source inventory, with zero for TPM, PM_{10}, $PM_{2.5}$, NO_x and CO. Emissions for SO_x and VOCs were not, however, reported in the point source inventory and thus have been assigned values determined by the area source estimation.

5.3.7   References

Environment Canada. 1976. Advances in Small-Scale Refuse Incinerators — Seminar Proceedings. Report EPS-3-EC-76-10. Solid Waste Management Branch, Environmental Conservation Directorate, Environment Canada.

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US Environmental Protection Agency (EPA).   2003.   Draft Dioxin Reassessment. (http://cfpub.epa.gov/ncea/cfm/part1and2.cfm?ActType=default)

U.S. EPA. 1996. FIRE (Factor Information Retrieval Data System) version 5.1, 5.2 and 6.25. Clearinghouse for Inventories & Emissions Factors, Technology Transfer Network, U.S. Environmental Protection Agency. (www.epa.gov/ttn/chief/software/fire/)

5.3.8   Guidebook Sector Documentation Record

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Author: Patrick Georges, Pollution Data Division

CHAPTER 6
MISCELLANEOUS SOURCE SECTOR

MISCELLANEOUS SOURCE SECTOR

6.1   CIGARETTE SMOKING 2006

6.1.1   General Description

In 2006, smoking rates in Canada continue to decrease since regular monitoring of smoking began in 1965. An estimated 4.93 million people, or 18.6% of the population 15 years of age and older, were smokers in 2006. Nationally 20.3% of the male population are smokers, while 17.% of the female population are smokers. On average, males smoke more cigarettes daily than females (Health Canada 2002).

6.1.2   Sector Description

Cigarette smoking produces emissions that include particulate, CO, VOCs, ammonia, heavy metals, dioxins and furans, and polycyclic aromatic hydrocarbons. In various scientific studies on cigarette smoking, two separate paths by which these contaminants are released into the atmosphere have been identified. One is mainstream cigarette smoke, which is directly exhaled by the smoker, and the other is sidestream smoke, which is directly released from burning cigarettes. Composite emission factors are obtained by adding the mainstream and sidestream emission factors together.

6.1.3   Inventory Method

Uncontrolled CAC and ammonia emission factors were obtained from 4 separate scientific articles and are summarized in Table 6.1-1. These are the values used to calculate cigarette smoking emissions.

Table 6.1-1: CAC and Ammonia Emission Factors for Cigarette Smoking

Source	Emission factors					
	TPM (mg/cigarette)[1]	PM10 (mg/cigarette)[1]	PM$_{2.5}$ (mg/cigarette)[1]	VOC (mg/cigarette)[2]	CO (mg/cigarette)[3]	NH3 (kg/person)[4]
Mainstream smoke				0.06	22.00	
Sidestream smoke				0.25	66.00	
Composite value	18.60	18.60	18.60	0.31	88.00	0.0177

Notes:
1.   Emission factors for particulate obtained from Ott et al. (1996).
2.   Emission factors for VOCs obtained from Wallace et al. (1987). VOCs considered in the study included the aromatic compounds benzene, styrene, xylenes and ethylbenzene and the straight-chain hydrocarbon octane.
3.   Emission factors for CO obtained from Ott et al. (1992).
4.   Emission factors for Ammonia obtained from Roe et al (2004).

Uncontrolled heavy metal emission factors were found using a scientific journal article by Gray & Boyle (2002). Table 6.1-2 presents the emission factors used to help calculate heavy metal emissions.

Table 6.1-2: Heavy Metal Emission Factors for Cigarette Smoking

Source	Emission factors (mg/cigarette)		
	Hg	Cd	Pb
Cigarette Smoking	0.0000049	0.0001370	0.0000522

The uncontrolled dioxin and furan emission factor comes from a document by the US EPA (2003). Table 6.1-3 summarizes this emission factor.

Table 6.1-3: Dioxin and Furan Emission Factors for Cigarette Smoking

Source	Emission factors (pg/cigarette)
	I-TEQ
Cigarette Smoking	0.43

Uncontrolled PAH emission factors are from the scientific journal report by Ding et al (2005). Table 6.1-4 summarizes these emission factors.

Table 3.1-5: Poly Aromatic Hydrocarbon Emission Factors for Cigarette Smoking

Source	Emission factors (ng/cigarette)			
	B(a)p	B(b)f	B(k)f	I(cd)p
Cigarette Smoking	10.30	11.62	2.2	

Using the emission factors summarized in Tables 6.1-1 to 6.1-4 emissions were calculated by multiplying the emission factors by the number of cigarettes in each province/territory.

6.1.4   Activity Level

In order to estimate the emissions from cigarette smoking, estimates of the total number of smokers by province/territory as well as their consumption level are needed. Health Canada conducts annual monitoring surveys of Canadian tobacco use. The 2006 survey (Health Canada 2006) contained data on the total number of smokers in each province/territory and the average number of cigarettes smoked each day. Multiplying these two numbers and then multiplying by 365 days/year, the total number of cigarettes smoked in a province is found.

For each pollutant, except ammonia, the calculated number of yearly cigarettes smoked is multiplied by its respective emission factor to estimate emissions. Ammonia's emissions are calculated using the population of smokers.

6.1.5 Comparison of 2006 Methods with Previous Methodology

The methodology used in 2006 is identical to the methodology used in 2005.

6.1.6 Alternative Methods Used by Provinces/Territories

No alternative methods were used by the provinces or territories

6.1.7 References

Ding et al. 2005. Determination of 14 Polycyclic Aromatic Hydrocarbons in Mainstream Smoke from Domestic Cigarettes. Environmental Science Technology 39. pp 471-478.

Gray, N. and Boyle P. 2002. Heavy Metals Range of Emissions from 26 Selected Brands. Annals of Oncology 13. pp 19-21

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U.S. EPA. 1992. Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders. EPA/600/6-90/006F. U.S. Environmental Protection Agency.

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Wallace, L., Pellizzari, E., Hartwell, T., Perrit, R. and Ziegenfus, R. 1987. Exposures to Benzene and Other Volatile Compounds from Active and Passive Smoking. Archives of Environmental Health 42(5): 272–279.

6.1.8   Guidebook Sector Documentation Record

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Author: Christine George, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.2   DRY CLEANING

6.2.1   General Description

The dry cleaning sector has undergone many changes over the years resulting in reduced levels of volatile organic compound (VOC) emissions being produced from this small sector. In Canada, many dry cleaners are taking measures, such as improving operating practices, modernizing equipment, changing dry cleaning solvents or initiating recycling programs, with the intent of protecting the environment of the communities in which they operate. Green dry cleaners are offering consumers environmentally preferable cleaning processes, such as cleaning clothes in water instead of solvent (wet cleaning) as well as phasing out the use of perchloroethylene (Canadian Centre for Pollution Prevention 2004). Note that perchloroethylene is no longer inventoried for this sector, as it is no longer considered a VOC.

6.2.2   Sector Description

The dry cleaning process involves the handling of solvents, typically either naphtha-based or perchloroethylene, in the washing, drying and solvent recovery operations. Since perchloroethylene is no longer considered a VOC, the emissions from dry cleaning processes have been largely reduced.

6.2.3   Inventory Method

Dry cleaning involves the cleaning of fabrics with non-aqueous organic solvents. The process generally involves three principal steps identical to those of ordinary laundering in water: washing the fabric in solvent one or more times, extraction of the excess solvent, often by spinning, and drying the cleaned fabric in ovens or hot air streams (Lee et al. 1990).

Solvent emissions are estimated based on the type and quantity of solvents used in dry cleaning operations. It is assumed that any solvent that is not recycled is emitted to the atmosphere.

The Pollution Data Division (PDD) has routinely hired a consultant with expertise in calculating solvent emissions to compile a comprehensive inventory for the sectors involved, including dry cleaning. The resulting solvent use VOC emissions inventory is then incorporated into the National Air Pollutant Inventory. The most recent emissions inventory completed under contract for PDD was by Cheminfo Services and Camford Information Services in 2007, which provided a comprehensive 20-year solvent VOC emission trend for the years 1985 to 2005. This latest trend inventory covers 29 commercially sold solvents defined as volatile organic compounds under the Canadian Environmental Protection Act. In addition, the inventory contains 9 major application

categories that are further broken down into various sub-categories. Provincial/territorial emissions are provided at the sub-category level for the year 2005 only, with total values for all three territories provided as a whole. Please see the report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007 for additional information.

For the compilation of the 2006 emission estimates, provincial/territorial VOC emissions from dry cleaning were estimated by using data provided in the 2007 study discussed above. Average annual growth rate percentages were calculated by using the 20-year trends data and the following formula:

$$Average\ Annual\ Growth\ Rate = \left\{ \left(\frac{Ending\ Value}{Beginning\ Value} \right)^{\left(\frac{1}{n}\right)} - 1 \right\} * 100$$

where n is the number of years.

For the dry cleaning sector, an average annual growth rate of -6.5% was calculated. This annual growth percentage was applied to the 2005 national estimates to grow the emissions for the year 2006. The resulting 2006 national emissions were then distributed amongst the provinces/territories and the various application sub-categories based on the distribution of emissions in the 2005 inventory. In order to estimate emissions for the territories individually, the total emissions at the sub-category levels were distributed to the Yukon, Northwest Territories and Nunavut based on population (Statistics Canada 2007).

To understand the method used to reconcile or remove the potential for double counting that existed when the 2006 VOC emissions from dry cleaning were combined with the dry cleaning VOC emissions reported to the 2006 National Pollutant Release Inventory (NPRI), please review the document entitled "*Compilation Procedure: VOC Emissions from Solvent Use, National Air Pollutant Emissions Inventory, 2005-2007*", Environment Canada, March 2009.

6.2.4   Activity Levels

The solvent use VOC trends inventory, from which the 2006 emissions were estimated, was developed through the application of the following top-down and bottom-up methodological steps (Cheminfo Services Inc. and Camford Information Services Inc. 2007):

- performing a Canadian supply and demand mass balance for each of 29 solvents for 1985-2005;
- segmenting total Canadian domestic demand into application areas for each solvent based on historical application shares;

- conducting bottom-up field research among major solvent suppliers and users in allocation areas to determine solvent use, controls, emissions and trends;
- comparing and combining market data, economic information and other information gathered from field research with mass balance data and estimating total solvent consumption and related VOC emissions in each application;
- applying application specific control efficiencies to solvent use estimates to calculate national VOC solvent emission estimates; and
- applying economic data and other information to allocate national solvent VOC emissions to provinces/territories.

For more information on the activity data used to calculate the VOC emission estimates from the solvent use sectors, please consult the Cheminfo/Camford Information Services report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007.

6.2.5 Comparison of 2006 Methods with Previous Methodology

As outlined in section 6.2.3, the calculation and application of an average annual growth rate percentage was required to estimate VOC emissions from dry cleaning for 2006; however, this was not the case for the previous year's inventory. For the year 2005, VOC emissions from dry cleaning were taken directly from the trends inventory report produced by Cheminfo Serices and Camford Information Services (2007).

6.2.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces for this sector.

6.2.7 References

Canadian Centre for Pollution Prevention. 2004. Green Dry Cleaner. (www.c2p2online.com/main.php3?section=139&doc_id=295&session=)

Cheminfo Services Inc. and Camford Information Services Inc. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005. Final Report, Prepared for Environment Canada, March 2007.

Cheminfo Services Inc. and Camford Information Services Inc. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #3: Mapping of Solvent Application Sub-Categories to NAICS Codes. Final Report, Prepared for Environment Canada, March 2007.

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Lee, N., Edwards W.C. and Herbert, D.J. 1990. Reduction of VOC Emissions from Solvents by Product Substitution, Process Changes or Add-On Controls. Prepared by B.H. Levelton & Associates Ltd. for Environment Canada.

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6.2.8   Guidebook Sector Documentation Record

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Author: Susan Charles, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.3 PESTICIDE AND FERTILIZER APPLICATION

6.3.1 General Description

Canada is both a major producer and a major user of fertilizers. The industry produces approximately 24 million tonnes of nitrogen, phosphate and potash, 18 million tonnes of which are exported. In addition, there are 5 million tonnes of elemental sulfur exports. Overall, Canada supplies over 70 countries with 12% of the world's fertilizers (CFI 2004).

Pesticides, including herbicides, insecticides and fungicides, are widely used in agriculture. Pesticide use in Canada may be declining, while commercial fertilizer use increased by 42% between 1980 and 1997. Boyd (2001) claims that Canada's record on environmental issues related to agriculture is poor enough to rank the country 22nd out of 28 OECD nations on the use of pesticides and 25th out of 28 on the use of commercial fertilizers.

6.3.2 Sector Description

Pesticides broadly include any substance used to kill or retard the growth of insects, weeds, fungi, rodents or microorganisms. Pesticides fall into three general categories: synthetics, non-synthetics (petroleum-based) and inorganics. Pesticides are typically applied in a powder or liquid form in which the active ingredient is dispersed or dissolved in inert diluents.

Fertilizers are chemicals that enhance the growth and development of crops and are typically applied in a liquid or granular form. During handling at the point of application and during application, particulate, either from the coating material or formed through attrition, is entrained by air turbulence and transported to distances determined primarily by the particle size distribution and the prevailing meteorology.

Particulate is the primary emission from pesticide and fertilizer applications considered in this inventory. The province of British Columbia, in addition to estimating particulate emissions, has estimated NO_x and VOC emissions. Canadian emissions for other provinces and territories for these two pollutants will be provided in the future.

6.3.3 Inventory Method

Emissions from pesticide application are not estimated at this time. Emissions resulting from fertilizer application are estimated by multiplying an emission factor by an activity level. Emission factors for particulate originating from fertilizer applications are based on uncontrolled emission factors and are given in Table 6.3-1.

Table 6.3-1: Emission Factors[1] for Fertilizer Application

Stage	Emission factors (kg/t)		
	Uncontrolled TPM	Uncontrolled PM_{10}	Uncontrolled $PM_{2.5}$
Bulk handling and storage	0.50		
Spreading	1.98		
Global emission factor	2.2300	1.0927[2]	0.3122[2]

Notes:
1. References: U.S. National Air Pollution Control Administration (1970); U.S. EPA (1973).
2. Emission factors for PM_{10} and $PM_{2.5}$ are from the U.S. EPA PM Calculator, where PM_{10} EF = 0.49 · TPM EF and $PM_{2.5}$ EF = 0.14 · TPM EF.

6.3.4 Activity Level

Activity levels are the nitrogen content of commercial fertilizer sold in province from July 1, 2005 to June 30, 2006. Data provided in retail sales statistics from Canadian Fertilizer information system (Numbers are % change based on 2004 sales figures).

6.3.5 Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 2005 inventory for this sector.

6.3.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces for this sector.

6.3.7 References

AAFC. 2001. Canadian Fertilizer Consumption, Shipments and Trade 1999/2000. Agriculture and Agri-Food Canada.

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6.3.8   Guidebook Sector Documentation Record

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Author: Diep Le / Susan Charles, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.4   FUEL MARKETING 2006

6.4.1   General Description

Fuel marketing is divided into three sectors: marketing terminals, bulk plants and service stations.

A survey by Levelton Engineering Ltd. (2001) for the Canadian Petroleum Products Institute provided the number of marketing terminals and bulk plants in 1998, as summarized in Table 6.4-1.

Table 6.4-1: Marketing Terminals and Bulk Plants in 1998, by Province/Territory

Province/territory	Number of marketing terminals	Number of bulk plants
Newfoundland and Labrador	14	21
Prince Edward Island	1	5
Nova Scotia	2	36
New Brunswick	4	15
Quebec	17	36
Ontario	25	126
Manitoba	3	79
Saskatchewan	3	147
Alberta	5	176
British Columbia	17	142
Territories	7	8
Canada	98	791

In 2000, service station fuel volumes were the largest in Ontario, with Quebec and British Columbia having the next highest volumes. These three provinces accounted for approximately 75% of fuel sales in Canada.

6.4.2   Sector Description

This sector covers fugitive VOC emissions from bulk distribution terminals, bulk plants and service stations. Volatile components of fuels are emitted as fuel moves from the refinery to the end user whenever tanks are filled or emptied or while tanks are open to the atmosphere, be they large above-ground tanks, tank trucks, railcars or underground tanks at service stations. In addition, emissions occur from evaporation of fuels spilled during transfer operations.

The fuel marketing network is complex. As fuels are moved from source to end user, various sizes and types of tanks and modes of transport are used, each with their own particular emission characteristics. These differences are further affected by seasonal changes in fuel properties and climate (Edwards and Cotton 1988). Of the two fuels, gasoline and diesel, the vast majority of VOC emissions occur from gasoline as a result of its much higher vapour pressure.

6.4.3   Inventory Method

For the 2006 inventory, VOC emissions for commercial fuel combustion were estimated using data provided in a study conducted by Telcsult as well as emission factors derived by the CAC section in 1995. The terminal and bulk stations are divided into loading and storage emissions, where the service stations are further separated by underground refilling emissions and vehicle fuelling and spillage.

For the terminal stations, the loading emissions were calculated by multiplying the 2004 data from the Tecsult report with a growth factor for 2006. Where thee storage emissions were estimated by multiplying the 1988 storage emissions (with a reduction factor), by the growth factor for 2006.

The bulk plant emissions where calculated by multiplying the 2006 CANSIM gross sales of gasoline by the emission factors which where derived by the CAC section in 1995- based on the 1988 emissions contained in the CPPI report. It was estimated that 70% of the bulk plant emissions where produced by storage and only 30% of the emissions where produced by loading.

For the service stations, the loading emissions where estimated by multiplying the 2004 data from the Tecsult report with a growth factor for 2006. The storage emissions where estimated by multiplying the 1988 service storage emissions (with a reduction factor), by the growth factor for 2006.

6.4.4   Activity Level

The 2006 provincial and territorial activity levels were obtained from Statistics Canada (Statistics Canada, Sales of fuel used for road motor vehicles, province and territories, 2006).

6.4.5   Comparison of 2006 Methods with Previous Methodology

In a CPPI report (CPPI 1991) and subsequent update, emissions from the fuel marketing sector were estimated for 1988 and updated for 1990. Most of the emissions from this sector, however, were distributed by plants (i.e. point sources) and not as area sources. The reported 1990 emissions were regrouped so that area source emission estimates for distribution terminals, bulk plants, and service stations were obtained. Using these 1990 provincial emissions in conjunction with 1990 provincial fuel sales data compiled by Statistics Canada, emission factors were calculated for each province and each category.

These emission factors were utilised in 1995 to obtain the emissions for that year by multiplying these emission factors by the 1995 Fuel Sales. The emissions from this sector for the year 2000 were obtained by prorating the 1995 emissions with provincial and territorial growth factors based on gross sales of gasoline. Emissions from this sector for the year 2002 were obtained by prorating the emissions for the year 2000 with Informetrica Growth Factors. The 2003, 2004 and 2005 Inventory emissions were forecasted.

6.4.6   Alternative Methods Used by Provinces/Territories

Documentation of the methods used to estimate emissions in the Lower Fraser Valley is included in the report *2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed* (GVRD and FVRD 2003). This is an alternate method to the one outlined in previous sections and can be used for British Columbia.

6.4.7   References

CPPI. 1991. Atmospheric Emissions from Canadian Petroleum Refineries and the Associated Gasoline Distribution System for 1988. CPPI Report No. 91-7. Canadian Petroleum Products Institute.

Edwards, W.C. and Cotton, T. 1988. VOC Emissions Methods Manual. Prepared by B.H. Levelton & Associates Ltd. for Environmental Analysis Branch, Environment Canada.

GVRD and FVRD. 2003. 2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed. Detailed Listing of Results and Methodology. Greater Vancouver Regional District and Fraser Valley Regional District. November. (www.gvrd.bc.ca/publications/file.asp?ID=684)

Levelton Engineering Ltd. 2001. Update of Air Emissions from CPPI Terminals and Bulk Plants. April.

Statistics Canada. Sales of Gasoline Used for Road Motor Vehicles, Provinces and Territories. CANSIM II, Table 405-0002. (http://cansim2.statcan.ca/cgi-win/cnsmcgi.exe?CANSIMFile=CII/CII_1_E.HTM&RootDir=CII/)

Statistics Canada, CANSIM, table 405-0002.. Sales of fuel used for road motor vehicles, by province and territory (http://www40.statcan.ca/l01/cst01/trade37c.htm)

Tecsult Inc 2006. Study on gasoline vapour recovery in Stage1 distribution networks in Calnada

6.4.8   Guidebook Sector Documentation Record

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MISCELLANEOUS SOURCE SECTOR

6.5   GENERAL SOLVENT USE

6.5.1   General Description

General solvent use is a broad and diverse source of volatile organic compound (VOC) emissions. Solvents in this sector are used for a variety of purposes in every province and territory in Canada and at nearly every industrial, residential, commercial and institutional site across the country.

Solvents used in this sector for industrial applications are mainly naphthas and alcohols, and are utilized for general purpose cleaning, while various specialized applications require significant quantities of aromatics, ketones, ethers and esters. Growth in emissions from economic activity has been offset in some applications by increases in solvent recycling practices and some substitution with VOC solvents, but this type of activity is limited.

Consumer and commercial applications include many different uses of solvent in both household and commercial settings, as well as many consumer products that are not applied in households (e.g., windshield washer fluid). Solvents predominantly used in consumer and commercial applications are alcohols, which are utilized in many formulated products, such as windshield washer fluid, household products and personal care products. Other solvents emitted in high volumes from consumer and commercial applications include naphthas, which are especially used in cleaning products.

6.5.2   Sector Description

The general solvent use sector covers processes whereby fugitive VOC emissions can result from industrial, commercial, institutional and residential uses of solvent.

Numerous industries use solvents as raw materials for product manufacture, as transfer agents or diluents, as wash-up material, as refrigerants or as by-products. The primary emissions from this sector are VOC.

6.5.3   Inventory Method

The Pollution Data Division (PDD) has routinely hired a consultant with expertise in calculating solvent emissions to compile a comprehensive inventory for the sectors involved, including general solvent use. The resulting solvent use VOC emissions inventory is then incorporated into the National Air Pollutant Inventory. The most recent emissions inventory completed under contract for PDD was by Cheminfo Services and Camford Information Services in 2007, which provided a comprehensive 20-year solvent VOC emission trend for the years 1985 to 2005. This latest trend inventory covers 29

commercially sold solvents defined as volatile organic compounds under the Canadian Environmental Protection Act. In addition, the inventory contains 9 major application categories that are further broken down into various sub-categories. Provincial/territorial emissions are provided at the sub-category level for the year 2005 only, with total values for all three territories provided as a whole. Please see the report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007 for additional information.

For the compilation of the 2006 emission estimates, provincial/territorial VOC emissions from general solvent use were estimated by using data provided in the 2007 study discussed above. Average annual growth rate percentages were calculated by using the 20-year trends data and the following formula:

$$Average\ Annual\ Growth\ Rate = \left\{ \left(\frac{Ending\ Value}{Beginning\ Value} \right)^{\left(\frac{1}{n} \right)} - 1 \right\} * 100$$

where n is the number of years.

Table 6.5-1 presents the average annual growth rates calculated for the general solvent use sector which includes the sub-categories of: Degreasing, Other Industrial, Other Consumer and Commercial, Pesticides, Personal Care Products and Household Products. These average annual growth rate percentages were applied to the 2005 national estimates to grow the emissions for the year 2006. The resulting 2006 national emission estimates were then distributed amongst the provinces/territories and the various application sub-categories based on the distribution of emissions in the 2005 inventory. In order to estimate emissions for the territories individually, the total emissions at the sub-category levels were distributed to the Yukon, Northwest Territories and Nunavut based on population (Statistics Canada 2007).

Table 6.5-1: Average Annual Growth Rate Percentages for General Solvent Use

Major Application Category	Average Annual Growth Rate Percentages
Degreasing	0.5%
Other Industrial	1.2%
Other Consumer and Commercial	2.6%
Pesticides	1.7%
Personal Care Products	1.3%
Household Products	2.1%

To understand the method used to reconcile or remove the potential for double counting that existed when the 2006 VOC emissions from general solvent use were combined with the general solvent use VOC emissions reported to the 2006 National Pollutant Release Inventory (NPRI), please review the document entitled *"Compilation Procedure: VOC*

Emissions from Solvent Use, National Air Pollutant Emissions Inventory, 2005-2007",
Environment Canada, March 2009.

6.5.4   Activity Levels

The solvent use VOC trends inventory, from which the 2006 emissions were estimated, was developed through the application of the following top-down and bottom-up methodological steps (Cheminfo Services Inc. and Camford Information Services Inc. 2007):

* performing a Canadian supply and demand mass balance for each of 29 solvents for 1985-2005;
* segmenting total Canadian domestic demand into application areas for each solvent based on historical application shares;
* conducting bottom-up field research among major solvent suppliers and users in allocation areas to determine solvent use, controls, emissions and trends;
* comparing and combining market data, economic information and other information gathered from field research with mass balance data and estimating total solvent consumption and related VOC emissions in each application;
* applying application specific control efficiencies to solvent use estimates to calculate national VOC solvent emission estimates; and
* applying economic data and other information to allocate national solvent VOC emissions to provinces.

For more information on the activity data used to calculate the VOC emission estimates from the solvent use sectors, please consult the Cheminfo/Camford Information Services report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007.

6.5.5   Comparison of 2006 Methods with Previous Methodology

As outlined in section 6.5.3, the calculation and application of average annual growth rate percentages were required to estimate VOC emissions from general solvent use for 2006; however, this was not the case for the previous year's inventory. For the year 2005, VOC emissions from general solvent use were taken directly from the trends inventory report produced by Cheminfo Serices and Camford Information Services (2007).

Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces for this sector.

6.5.7   References

Canadian Centre for Pollution Prevention. 2004. Green Dry Cleaner.

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Environment Canada 2009. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005. April 2009.

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6.5.8   Guidebook Sector Documentation Record

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Author: Susan Charles, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.6 MEAT COOKING

6.6.1 General Description

Central Canada (Ontario and Quebec) represents over 60% of commercial and residential cooking of meat across all types of meat and cooking methods. British Columbia and Alberta account for an additional 20% of residential and commercial meat cooking.

6.6.2 Sector Description

The residential and commercial cooking of meat has been documented to be a source of fine particulate emissions. Particulate emissions from meat cooking are dependent on the grade of the boneless red meat (i.e., lean or regular ground meat) and the cooking method (i.e., charbroiling or frying). Boneless red meat is divided into three categories: beef, veal and lamb.

6.6.3 Inventory Method

The particulate emissions from meat cooking on a provincial/territorial basis are obtained by multiplying the quantity of boneless red meat by an emission factor. Emission factors for meat cooking are given in Table 6.6-1 for three combinations of boneless red meat grade and cooking method.

Table 6.6-1: Fine Aerosol Emission Factors for Meat Cooking

Cooking method and boneless red meat grade	TPM emission factors (g/kg)
Charbroiled regular boneless red meat	40
Charbroiled lean boneless red meat	7
Fried boneless red meat	1

Ref: Rogge et al. (1991)

It is assumed that the emission factors for TPM, PM_{10} and $PM_{2.5}$ are all the same.

6.6.4 Activity Level

The 2006 provincial/territorial populations were obtained from Statistics Canada (Statistics Canada, Population by year, province and territories, 2006). The annual consumption of beef, veal and mutton/lamb was taken to be 21.8, 0.92 and 21.39 kg/person, respectively. Beef Information Centre, 1996
Fish (9.57 kg/person) and Poultry (22.80 kg/person) were added to these meats. (Statistics Canada, Food Consumption in Canada, 2004).

In addition, it has been assumed that 40% of all meat is consumed in restaurants, with the remainder falling under residential consumption. For both residential and commercial operations, it is also assumed that only 9% of all meat is charbroiled, while the rest is fried.

6.6.5   Comparison of 2006 Methods with Previous Methodology

The emission factors are the same as for previous years.

6.6.6   Alternative Methods Used by Provinces/Territories

British Columbia's methodology for emissions from the frying and charbroiling of meat was developed as part of a trace air contaminants study (B.H. Levelton & Associates Ltd. 1995). The emission factors are the same as in other provinces/territories. More information is included in the document *2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed* (GVRD and FVRD 2003).

6.6.7   References

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B.H. Levelton & Associates Ltd. 1995. Inventory of Sources and Emissions of Trace Air Contaminants in B.C. for 1990.

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Rogge, W.F., Hildemmann, L.M., Mazurek, M.A. and Cass, G.R. 1991. Sources of Fine Organic Aerosol. 1. Charbroiling and Meat Cooking Operations. Environmental Science and Technology 25: 1112–1125.

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6.6.8   Guidebook Sector Documentation Record

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Date: June 2008

Author: Patrick Georges, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.7   PRINTING

6.7.1   General Description

The printing sector experienced significant growth between 1985 and 2005, from 34 to 42 kt or 24% over the 20 year period (Cheminfo Services and Camford Information Services 2007). This trend included both:

- industrial printing (large-volume printing presses on various substrates); and
- commercial printing (primarily small- to medium-sized enterprises catering to small business printing requirements on paper and cardboard substrates).

There has been rapid growth in the overall use of flexography printing due to improved print quality and growth in solvent-intensive flexographic printing on plastic substrates. Emissions from lithography have declined slowly over time, in part due to reduced use of isopropanol fountain solutions used in lithographic printing. At the same time, lithographic printers have applied pollution prevention practices to reduce use and increase recycling of cleaning solvents.

The printing of plastics, metal foil and paper packaging materials are large sources of volatile organic compounds (VOC) emissions. Packaging applications account for nearly two-thirds of VOC emissions from printing presses in Canada. Printing of magazines, newspapers, flyers, books, calendars, annual reports and many other readable paper items are the other major applications categories of VOC emissions.

6.7.2   Sector Description

Printing inks and associated printing coatings consist of pigments, composed of organic and inorganic material to produce desired colours; solid components or binders, composed of organic resins and polymers to lock the pigment to the paper; and solvents, usually composed of organic compounds, to disperse the pigments and binders. VOC emissions from inks and other printing coatings, whether used in the commercial graphic art industries or used by individual customers, arise from the solvents used in printing inks.

The primary emissions from the printing sector are VOC.

6.7.3   Inventory Method

The Pollution Data Division (PDD) has routinely hired a consultant with expertise in calculating solvent emissions to compile a comprehensive inventory for the sectors involved, including printing. The resulting solvent use VOC emissions inventory is then incorporated into the National Air Pollutant Inventory. The most recent emissions

inventory completed under contract for PDD was by Cheminfo Services and Camford Information Services in 2007, which provided a comprehensive 20-year solvent VOC emission trend for the years 1985 to 2005. This latest trend inventory covers 29 commercially sold solvents defined as volatile organic compounds under the Canadian Environmental Protection Act. In addition, the inventory contains 9 major application categories that are further broken down into various sub-categories. Provincial/territorial emissions are provided at the sub-category level for the year 2005 only, with total values for all three territories provided as a whole. Please see the report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007 for additional information.

For the compilation of the 2006 emission estimates, provincial/territorial VOC emissions from printing were estimated by using data provided in the 2007 study discussed above. Average annual growth rate percentages were calculated by using the 20-year trends data and the following formula:

$$Average\ Annual\ Growth\ Rate = \left\{ \left(\frac{Ending\ Value}{Beginning\ Value} \right)^{\left(\frac{1}{n} \right)} - 1 \right\} * 100$$

where n is the number of years.

For the printing sector, an average annual growth rate of 1.1% was calculated. This annual growth percentage was applied to the 2005 national estimates to grow the emissions for the year 2006. The resulting 2006 national emissions were then distributed amongst the provinces/territories and the various application sub-categories based on the distribution of emissions in the 2005 inventory. In order to estimate emissions for the territories individually, the total emissions at the sub-category levels were distributed to the Yukon, Northwest Territories and Nunavut based on population (Statistics Canada 2007).

To understand the method used to reconcile or remove the potential for double counting that existed when the 2006 VOC emissions from printing were combined with the printing VOC emissions reported to the 2006 National Pollutant Release Inventory (NPRI), please review the document entitled "*Compilation Procedure: VOC Emissions from Solvent Use, National Air Pollutant Emissions Inventory, 2005-2007*", Environment Canada, March 2009.

6.7.4   Activity Levels

The solvent use VOC trends inventory, from which the 2006 emissions were estimated, was developed through the application of the following top-down and bottom-up methodological steps (Cheminfo Services Inc. and Camford Information Services Inc. 2007):

- performing a Canadian supply and demand mass balance for each of 29 solvents for 1985-2005;
- segmenting total Canadian domestic demand into application areas for each solvent based on historical application shares;
- conducting bottom-up field research among major solvent suppliers and users in allocation areas to determine solvent use, controls, emissions and trends;
- comparing and combining market data, economic information and other information gathered from field research with mass balance data and estimating total solvent consumption and related VOC emissions in each application;
- applying application specific control efficiencies to solvent use estimates to calculate national VOC solvent emission estimates; and
- applying economic data and other information to allocate national solvent VOC emissions to provinces/territories.

For more information on the activity data used to calculate the VOC emission estimates from the solvent use sectors, please consult the Cheminfo/Camford Information Services report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007.

6.7.5 Comparison of 2006 Methods with Previous Methodology

As outlined in section 6.7.3, the calculation and application of an average annual growth rate percentage was required to estimate VOC emissions from printing for 2006; however, this was not the case for the previous year's inventory. For the year 2005, VOC emissions from printing were taken directly from the trends inventory report produced by Cheminfo Serices and Camford Information Services (2007).

6.7.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

6.7.7 References

Cheminfo Services Inc. and Camford Information Services Inc. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005. Final Report, Prepared for Environment Canada, March 2007.

Cheminfo Services Inc. and Camford Information Services Inc. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #3: Mapping of Solvent Application Sub-Categories to NAICS Codes. Final Report, Prepared for Environment Canada, March 2007.

Environment Canada 2009. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005. April 2009.

Statistics Canada. 2007. Population by year, by province and territory. (http://www40.statcan.ca/l01/cst01/demo02a.htm).

6.7.8 Guidebook Sector Documentation Record

Release Version: 1

Date: April 2009

Author: Susan Charles, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.8   STRUCTURAL FIRES

6.8.1   General Description

In Canada, typically 39% of structural fires are residential fires, with special property fires (including vehicles) accounting for 36% and industrial and commercial fires accounting for just over 10% of all fires. Approximately 50% of all fires occur in Ontario and Quebec, with Alberta, British Columbia and Manitoba each accounting for just over 10% of the fires.

6.8.2   Sector Description

Structural fires include all fires that burn human-made edifices and vehicles. Structural fires emit large quantities of pollutants due to rapid, incomplete combustion. Quantification of these emissions is difficult, since the quantity and quality of smoke are highly dependent on the type of fuel burned (SNC/GECO Canada Inc. and Ontario Research Foundation 1981).

During structural fires, significant amounts of particulate matter (TPM, PM10, PM2.5), carbon monoxide (CO) and volatile organic compounds (VOCs) are emitted. Nitrogen oxides (NO_x) emissions are considered to be much lower, while sulphur oxides (SO_x) emissions are considered to be negligible.

6.8.3   Inventory Method

Emissions from structural fires were estimated as an area source using the emission factors provided in table 6.8-1 below.

Table 6.8-1: Emission Factors for Structure Fires

Source	Emission factors (kg/t)					
	TPM[1]	PM_{10}[1]	$PM_{2.5}$[1]	VOC[1]	CO[1]	NH_3[2]
Structure fires	5.4	5.4	5.0	5.5	30	0.315

Notes:
1. GVRD and FVRD (2003)
2. Battye et al (1994)

The emission factors listed above were multiplied by the tonnes of structure burned in each province/territory to obtain the tonnes of pollutant emitted.

6.8.4   Activity Levels

Structural fire activity levels were separated into 2 parts: number of structural fires and conversion to tonnes of structure burned. The first part consisted of the number of fires by property category and by province/territory. The property categories included residential, assembly, institutions, mercantile, industrial manufacturing, storage, special, farm and miscellaneous.

As of November 2008, the number of structural fires during 2006 was available for New Brunswick, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia as well as for two territories consisting of the Yukon and Nunavut. For the remaining provinces and territory, the most recent data available was used. Table 6.8-2 below provides a list of the most recent number of structural fires reported in each region, the year the data is based on and the source of the data.

Table 6.8-2: Activity Levels for Structural Fires

Province/Territory	Number of Structural Fires	Year	Source of Data
Newfoundland	422	10 year average	CCFMFC (2007) http://www.ccfmfc.ca/stats/en/report_e_02.p
Prince Edward Island	387	10 year average	CCFMFC (2007) http://www.ccfmfc.ca/stats/en/report_e_02.p
Nova Scotia	724	2002	CCFMFC (2007) http://www.ccfmfc.ca/stats/en/report_e_02.p
New Brunswick	2,764	2006	New Brunswick Office of the Fire Marshal (2006) http://www.gnb.ca/0276/fire/pdf/OFMAnnF p2006.pdf
Quebec	11,989	2005	Direction du developpement Ministere de la Securite publique Email communication
Ontario	15,368	2006	Ontario Office of the Fire Marshal (2008) http://www.ofm.gov.on.ca/english/publicati s/Statistics/2000_to_2005_all_fires.asp
Manitoba	6,035	2006	Manitoba's Office of the Fire Commissione Email correspondence
Saskatchewan	2,963	2006	Saskatchewan Fire Commissioner's Office (2006) http://www.cpsp.gov.sk.ca/2006FireComma .pdf
Alberta	2,744	2006	Alberta Emergency Management Agency Email correspondence
British Columbia	7,818	2006	BC Office of the Fire Commissioner Email Correspondence
Yukon	216	2006	Yukon Office of the Fire Marshal Email Correspondence
Northwest Territories	148	2002	CCFMFC (2007) http://www.ccfmfc.ca/stats/en/report_e_02.p
Nunavut	72	2006	Nunavut Office of the Fire Marshal Email Correspondence

The number of fires in a given province was multiplied by a loading factor to convert the number of fires into tonnes of structure burned. The loading factor used was 1.04 tonnes of structure burned per fire (EIIP 2001).

6.8.5 Comparison of 2006 Method with Previous Methodology

The only change made to the methodology for 2006 was related to the activity levels. For the 2005 inventory, many of the activity levels used in the estimations had been prorated from previous years' data. For the 2006 inventory, actual data collected from provincial fire statistics agencies was used for eight of the thirteen provinces/territories. For the remaining regions, data from the most recent year available was used.

6.8.6 Alternative Methods Used by Provinces/Territories

No alternative methods are used by the provinces or territories.

6.8.7 References

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Saskatchewan Fire Commissioner's Office. 2006. Annual Report. Saskatchewan Corrections and Public Safety. (http://www.cpsp.gov.sk.ca/2006FireCommAR.pdf)

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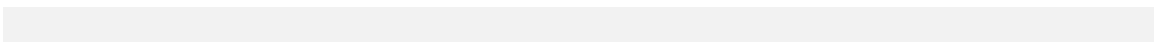
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6.8.8   Guidebook Sector Documentation Record

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Author: Susan Charles, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.9   SURFACE COATINGS

6.9.1   General Description

Although the value of domestic sales of architectural, automotive, other industrial, and maintenance paints and coatings have increased, the solvent use and average volatile organic compounds (VOCs) content have declined. This decline is a result of the increased adoption of water-based paints (especially for architectural applications), increased market penetration of powder coatings (especially for metal substrates) and improved application efficiency. The solids content in solvent-based products has also increased, thereby lowering the solvents content. At the same time, there has been a transition away from the use of aromatic solvents such as toluene and xylene in industrial applications.

Trends in retail consumer and trade architectural paint markets include a transition towards lower-odour solvent-based (alkyd) paints for exterior, bathroom and kitchen applications and a general move towards the use of water-based (latex) paints for all applications. All of these changes are resulting in lower VOC emissions being emitted from the surface coatings sector as a whole.

6.9.2   Sector Description

Surface coating operations primarily involve the application of paint, lacquer, varnish or paint primer for decorative or protective purposes. The major Canadian surface coating applicators include the automobile, strip, sheet and coil coatings and household appliance manufacturing industries (Environment Canada 1983). Emissions in this sector are not limited to commercial and consumer applications but include all industrial applications as well.

Emissions from the surface coatings sector are primarily limited to VOCs.

6.9.3   Inventory Method

The Pollution Data Division (PDD) has routinely hired a consultant with expertise in calculating solvent use emissions to compile a comprehensive inventory for the sectors involved, including surface coatings. The resulting solvent use VOC emissions inventory is then incorporated into the National Air Pollutant Inventory. The most recent emissions inventory completed under contract for PDD was by Cheminfo Services and Camford Information Services in 2007, which provided a comprehensive 20-year solvent VOC emission trend for the years 1985 to 2005. This latest trend inventory covers 29 commercially sold solvents defined as volatile organic compounds under the Canadian Environmental Protection Act. In addition, the inventory contains 9 major application categories that are further broken down into various sub-categories. Provincial/territorial emissions are provided at the sub-category level for the year 2005 only, with total values

for all three territories provided as a whole. Please see the report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007 for additional information.

For the compilation of the 2006 emission estimates, provincial/territorial VOC emissions from surface coatings were estimated by using data provided in the 2007 study discussed above. Average annual growth rate percentages were calculated by using the 20-year trends data and the following formula:

$$Average\ Annual\ Growth\ Rate = \left\{ \left(\frac{Ending\ Value}{Beginning\ Value} \right)^{\left(\frac{1}{n}\right)} - 1 \right\} * 100$$

where n is the number of years.

For the surface coatings sector, an average annual growth rate of -2.6% was calculated. This annual growth percentage was applied to the 2005 national estimates to grow the emissions for the year 2006. The resulting 2006 national emissions were then distributed amongst the provinces/territories and the various application sub-categories based on the distribution of emissions in the 2005 inventory. In order to estimate emissions for each territory individually, the total emissions at the sub-category levels were distributed to the Yukon, Northwest Territories and Nunavut based on population (Statistics Canada 2007).

To understand the method used to reconcile or remove the potential for double counting that existed when the 2006 VOC emissions from surface coatings were combined with the surface coatings VOC emissions reported to the 2006 National Pollutant Release Inventory (NPRI), please review the document entitled "*Compilation Procedure: VOC Emissions from Solvent Use, National Air Pollutant Emissions Inventory, 2005-2007*", Environment Canada, March 2009.

6.9.4   Activity Levels

The solvent use VOC trends inventory, from which the 2006 emissions were estimated, was developed through the application of the following top-down and bottom-up methodological steps (Cheminfo Services Inc. and Camford Information Services Inc. 2007):

- performing a Canadian supply and demand mass balance for each of 29 solvents for 1985-2005;
- segmenting total Canadian domestic demand into application areas for each solvent based on historical application shares;
- conducting bottom-up field research among major solvent suppliers and users in allocation areas to determine solvent use, controls, emissions and trends;
- comparing and combining market data, economic information and other information

gathered from field research with mass balance data and estimating total solvent consumption and related VOC emissions in each application;

- applying application specific control efficiencies to solvent use estimates to calculate national VOC solvent emission estimates; and

- applying economic data and other information to allocate national solvent VOC emissions to provinces/territories.

For more information on the activity data used to calculate the VOC emission estimates from the solvent use sectors, please consult the Cheminfo/Camford Information Services report entitled *"Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005"* Final Report, March 31, 2007.

6.9.5   Comparison of 2006 Methods with Previous Methodology

As outlined in section 6.9.3, the calculation and application of an average annual growth rate percentage was required to estimate VOC emissions from surface coatings for 2006; however, this was not the case for the previous year's inventory. For the year 2005, VOC emissions from surface coatings were taken directly from the trends inventory report produced by Cheminfo Serices and Camford Information Services (2007).

6.9.6   Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

6.9.7   References

Cheminfo Services Inc. and Camford Information Services Inc. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005. Final Report, Prepared for Environment Canada, March 2007.

Cheminfo Services Inc. and Camford Information Services Inc. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #3: Mapping of Solvent Application Sub-Categories to NAICS Codes. Final Report, Prepared for Environment Canada, March 2007.

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Environment Canada 2009. Volatile Organic Compound (VOC) Emissions from the Use of Solvents in Canada – Inventory Improvement and Trends Compilation - Task #2: VOC Emission Trends Compilation 1985-2005. April 2009.

Statistics Canada. 2007. Population by year, by province and territory. (http://www40.statcan.ca/l01/cst01/demo02a.htm).

6.9.8   Guidebook Sector Documentation Record

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Author: Susan Charles, Pollution Data Division

MISCELLANEOUS SOURCE SECTOR

6.10   HUMAN

6.10.1 General Description

This sector covers emissions of ammonia (NH_3) from human respiration and perspiration.

6.10.2 Sector Description

Waste products are formed in the human body during metabolism. These waste products, such as ammonia, hydrogen sulphide, mercaptans, carbon monoxide, hydrocarbons etc., are slowly excreted thorough the gastro-intestinal tract, kidneys, skin and lungs (Geadah 1985).

6.10.3 Inventory Method

An ammonia emission factor for human respiration and perspiration was obtained from the US EPA document entitled "Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources – Draft Final Report" (Roe et al. 2004).   A value of 0.0168 kg/person-yr was used.

6.10.4 Activity Level

Ammonia emissions from human respiration and perspiration were estimated by applying the emission factor listed in section 6.10.3 to the 2006 provincial/territorial population totals from Statistics Canada (Source: Statistics Canada, CANSIM, table (for fee) 051-0001). This provided an ammonia emission estimate for each province and territory.

6.10.5 Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the previous inventory.

6.10.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

6.10.7 References

Geadah, M. 1985. National Inventory of Natural and Anthropogenic Sources and Emissions of Ammonia (1980). Environmental Protection Programs Directorate, Environmental Protection Service, Environment Canada, Ottawa, Ontario.

Roe, S.M., Spivey, M.D., Lindquist, H.C., Thesing, K.B., Strait, R.P. and E.H. Pechan & Associates, Inc. 2004. Estimating Ammonia Emissions from Anthropogenic

Nonagricultural Sources – Draft Final Report. Prepared for the US Environmental Protection Agency's (EPA) Emission Inventory Improvement Program (EIIP).

Statistics Canada, CANSIM, table 051-0001. Population by year, by provinces and territories. (http://www40.statcan.ca/l01/cst01/demo02a.htm)

6.10.8 Guidebook Sector Documentation Record

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Author: Susan Charles, Pollution Data Division
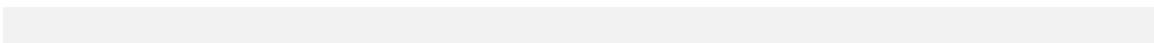
MISCELLANEOUS SOURCE SECTOR

6.11   OTHER MISCELLANEOUS SOURCES

6.11.1 General Description

This sector covers emissions of ammonia (NH_3) from two domestic sources. These sources include infant diapered waste and non-agricultural fertilizers.

6.11.2 Inventory Method

Ammonia emission factors for infant diapered waste and non-agricultural fertilizers were obtained from the US EPA document entitled "Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources – Draft Final Report" (Roe et al. 2004). Values of 0.0136 kg/infant-yr (for infants aged 0 to 3 years) and 0.0304 kg/person-yr were used, respectively.

6.11.3 Activity Level

Ammonia emissions from infant diapered waste were estimated by applying the emission factor to the 2005 provincial/territorial population totals for infants aged 0 to 3 years of age. The provincial/territorial populations of infants were obtained from the Statistics Canada publication "Annual Demographic Statistics 2005" (Statistics Canada 2006).

Ammonia emissions from non-agricultural fertilizers were calculated by applying the emission factor to provincial/territorial population totals for 2005 from Statistics Canada (Statistics Canada 2006).

6.11.4 Comparison of 2005 Methods with Previous Methodology

There were no changes to methodology from the previous inventory year.

6.11.5 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

6.11.6 References

Roe, S.M., Spivey, M.D., Lindquist, H.C., Thesing, K.B., Strait, R.P. and E.H. Pechan & Associates, Inc. 2004. Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources – Draft Final Report. Prepared for the US Environmental Protection Agency's (EPA) Emission Inventory Improvement Program (EIIP).

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6.11.7 Guidebook Sector Documentation Record

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Author: Susan Charles, Pollution Data Division

CHAPTER 7
OPEN SOURCE SECTOR

OPEN SOURCE SECTOR

7.1   AGRICULTURAL ANIMALS

7.1.1   General Description

Agricultural animals are divided into five groups: cattle and calves, pigs and hogs, sheep and lambs, poultry and horses. In 2006, Alberta had the largest population of cattle and calves in Canada with 39.22% more animals than the next two largest populations of Ontario (13.96%) and Saskatchewan (20.58%%) combined. Quebec and Ontario represented 28.23% and 24.86% of all the pigs and hogs in Canada, respectively. For sheep and lambs, Ontario, Alberta and Quebec represented 25.68%, 25.54% and 19.20% of the total number of animals, respectively. Central Canada had the highest proportions of the poultry population with 33.90% in Ontario and 25.35% in Quebec. The largest proportion of horses was in Alberta with 35%, followed by 18% in Ontario and 15% in Saskatchewan (Statistics Canada 2003).

7.1.2   Sector Description

This sector is primarily concerned with particulate and VOC emissions from agricultural animals. Particulate emissions from domestic animals result from the movement of cattle, hogs, sheep, pigs and horses in man-made enclosures such as pens and corrals as well as in fields and pastures. Ammonia emissions from agricultural animals are dealt with in a separate document.

7.1.3   Inventory Method

This sector was inventoried as an area source using appropriate emission factors and activity levels for particulate and VOC emissions.

For particulates, emission factors for cattle and calves were taken from AP-42, Version 4, Section 6.15 (U.S. EPA 1985). Emission factors for smaller animals, such as pigs and sheep, were assumed to be 10% of the cattle and calves emission factors based on the relative size, amount of movement and damage caused by the animal. The emission factors for horses were also derived from those for cattle and calves. The emission factors for poultry (includes turkeys) were obtained from the 2000 Greater Vancouver Regional District (GVRD) and the Fraser Valley Regional District (FVRD) area inventory (GVRD and FVRD 2003).

For VOCs, emission factors for hogs and pigs, sheep, poultry, turkeys and horses were taken from Table B.1.1 in the documentation for the 2000 emissions inventory for GVRD and FVRD (GVRD and FVRD 2003). The VOC emission factor for cattle and calves was generated by the Criteria Air Contaminants Division, Pollution Data Branch.

Table 7.1-1 summarizes the emission factors, in units of kilograms of pollutant per animal (except where indicated), for the various classes of animals.

Table 7.1-1: Emission Factors for Animals

Animals	Emission factors (kg/head)			
	TPM	PM_{10}	$PM_{2.5}$	VOCs
Cattle and calves	25.00	0.64*TPM[1]	0.1*TPM[1]	18.3
Hogs and pigs	2.50	1.60	0.25	0.2
Sheep	2.50	1.60	0.25	1.4
Poultry[2]	0.40	0.26	0.04	1.6
Turkeys[3]				
Horses	25.00	16.00	2.50	4.1

Note:
1. PM10 and PM2.5 emissions for cattle and calves are calculated as a percentage of the TPM emissions.
2. The emission factor for poultry is in units of kg/1000 head.
3. Turkey emissions are reported with poultry.

Emissions were calculated using the following formula:

$$E = (AL \times EF) \times F_C$$

where E is the emission in kilograms, AL is the activity level (number of animals) discussed in the next section, EF is the emission factor as given in Table 7.1-1 and F_C is a climate correction factor. For cattle and calves, the emission factors in Table 7.1-1 were developed for dry conditions with moderate wind speed. Use of the climate correction factor modifies the emissions for rainy conditions by assuming that there are no particulate emissions on a given day if at least 2.5 cm of rain accumulates during the day. Climate correction factors were compiled on a provincial and territorial basis. For all other animal types, no climate correction factor was used.

7.1.4 Activity Level

The activity level for this sector is the number of animals by type for each province. 2006 pullets data was not available at the time of compilation, therefore the data has been prorated from 2004. Cattle data was obtained from Stats Canada 23-012-XIE, Vol 5 no 1, Table 1. The sheep data was obtained from Stats Canada 23-011-XIE, Vol 5 no1, Table 1. The horse population was not available at the time of compilation, therefore the most recent data was used (2002). The poultry placement data are taken from Statistics Canada catalogue no 23-015-XIE April-June 2006, Tables 1 and 4-1. Activity data for hogs and pigs were taken from "Table 1. Pigs on Farms, Quarterly, by Province, East, West and Canada, 2006" from Statistics Canada - Cat. No. 23-010-XIE, 2006 vol. 5, no. 2

7.1.5 Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 2005 methodology for this sector.

7.1.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

7.1.7 References

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Statistics Canada. 2001. 2001 Census of Agriculture. Catalogue No. 95F0301-XIE.

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7.1.8 Guidebook Sector Documentation Record

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OPEN SOURCE SECTOR

7.2   AGRICULTURAL TILLING AND WIND EROSION

7.2.1   General Description

Saskatchewan and Alberta are the two provinces with the largest area of land subjected to tilling operations and agricultural wind erosion, accounting for more than two-thirds of all the activity in Canada. Ontario, Manitoba and Quebec have the next largest land areas under agricultural tilling operations.

7.2.2   Sector Description

This sector is primarily concerned with particulate emissions resulting from agricultural tilling and wind erosion. Emissions from fuel combustion in agricultural operations are inventoried as part of off-road use of diesel and gasoline.

Under this sector, particulate emissions resulting from all operations involved in the preparation, sowing, tilling and harvesting of fields are inventoried. This sector has the potential to emit large quantities of particulates to the atmosphere as the soil is worked. In addition, the sector inventories particulate emissions due to the entrainment of soil particles by the wind.

7.2.3   Inventory Method

This sector was inventoried as an area source using appropriate emission factors and activity levels for agricultural tilling and wind erosion.

Agricultural Tilling

Particulate emissions from agricultural tilling are proportional to the area tilled (U.S. EPA 1985). In addition, the emissions depend on the silt content of the soil, the speed and type of the tilling and the number of tills in a year.

A particulate emission factor can be calculated based on AP-42 (U.S. EPA 1985):

$$EF = 5.38 \cdot kS^{0.6}$$

where EF is the emission factor in units of kilogram per hectare tilled, k is the particle size multiplier (dimensionless) and S is the silt content of the surface soil. This equation is valid for silt contents between 1.7% and 88% and for tilling speeds between 8 and 10 km/h. Soil moisture is typically not an important factor for agricultural tilling, since most tilling events occur in dry to semidry conditions. Silt content of provincial and territorial soils were obtained from Agriculture Canada (1980/1985). Information on the average

particle size distribution was obtained from U.S. EPA (1985); k was 1.0 for total particulate matter, 0.21 for PM_{10} and 0.1 for $PM_{2.5}$.

The particulate emissions, E (tonnes), can then be estimated by:

$$E = EF \cdot A \cdot N / 1000$$

where N is the number of tilling events per year estimated from U.S. EPA (1985) and A is the modified tilling area, which depends on the type of tilling practice. The number of tilling events was 1 for all crop types. Three types of tilling practices are used in Canada: conventional tilling, where all vegetation residue is buried, conservation tilling, where 30% of the soil surface is covered by vegetation residue, and a "no-till" practice, where most of the soil surface is covered by vegetation residue. Data on provincial tilling practices were obtained from Dumanski et al. (1994) and are summarized in Table 7.2-1.

Table 7.2-1: Tillage Practice Distribution

Province	Tillage practice (%)		
	Conventional tilling	Conservation tilling	No tilling
Newfoundland and Labrador	87.7	8.3	4.4
Prince Edward Island	82.0	16.2	1.8
Nova Scotia	77.4	19.6	3.0
New Brunswick	79.5	18.4	2.1
Quebec	80.0	15.6	4.4
Ontario	78.0	18.0	4.0
Manitoba	66.0	29.0	5.0
Saskatchewan	45.0	33.0	22.0
Alberta	56.8	32.8	10.4
British Columbia	65.5	24.4	10.1

Wind Erosion

Particulate emissions due to wind erosion of agricultural soils depend on five broad factors: soil erodibility I (tons/acre per year), a surface roughness factor K (dimensionless), a climate factor C (dimensionless), an unsheltered field width factor L′ (dimensionless) and a vegetative cover factor V′ (dimensionless) (U.S. EPA 1988).

Soil erodibility is a function of the soil texture and the diameter of soil particles. Information regarding soil erodibility was obtained from Evans and Cooper (1980).

The surface roughness factor accounts for the resistance to wind erosion due to the presence of ridges, furrows and large clods and is specific to the type of crop grown. Data for the surface roughness factor were obtained from U.S. EPA (1988).

The climate factor accounts for the effects of differing wind speeds and the soil moistures on the ability of the wind to suspend soil particles. Provincial and territorial climate

factors were derived using internal data from the 1980 and 1985 criteria air contaminants inventory working files on climatic factors (Agriculture Canada 1980/1985).

The unsheltered field width factor and the vegetative cover factor are functions of the width of the uncovered field and the vegetation cover, respectively, as well as the soil erodibility, surface roughness factor and climate factor.

Using all these factors, an emission factor, EF (kg/ha), for wind erosion can then be estimated using (U.S. EPA 1988):

$$EF = A \cdot I \cdot K \cdot C \cdot L' \cdot V'$$

where A is the measured particulate portion (A = 0.025 for total suspended particulate, 0.0125 for PM_{10} and 0.000 25 for $PM_{2.5}$).

Particulate emissions due to wind erosion can then be estimated by multiplying the emission factor by the crop area (ha).

The average (over all crop and soil types) emission factor developed for each of the provinces in the 1985 inventory was used for the 1995, 2000 and 2002 inventories.

7.2.4 Activity Level

The 2006 activity level for both agricultural tilling and wind erosion is the area in each province that is planted with crops. Statistics Canada Catalogue No. 22-002-XIB was used to obtain the provincial areas of agricultural lands (i.e. crop areas seeded) for principal field crops, with the exception of potatoes, tobacco and vegetables..

Tobacco seeded areas were taken from Table 5 in Statistics Canada Catalogue No. 22-003-XIB (June 2005), "Fruit and Vegetable Production" and assumed to be same as 2004 and potato seeded areas were taken from Stats Can Catalogue No. 22-008-XIE "Potato Production", July 2006, vol. 4, no. 1).

7.2.5 Comparison of 2006 Methods with Previous Methodology

There were no changes from the 2006 methodology for this sector; however, emissions resulting from the tilling of land for vegetable crops were included for the first time in the 2002 inventory.

7.2.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

7.2.7 References

Agriculture Canada. 1980/1985. Criteria Air Contaminants (CAC) Inventory Development. Internal file from Agriculture Canada regarding silt content of soils.

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7.2.8   Guidebook Sector Documentation Record

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Author: Diep Le / Susan Charles, Pollution Data Division

OPEN SOURCE SECTOR

7.3 BIOGENIC EMISSIONS

7.3.1 General Description

Emissions from natural sources play an important role in the process of photochemistry of the lower atmosphere. Indeed, studies show that emissions from natural sources can exceed anthropogenic emissions, and their contribution must therefore be taken into account when assessing regional atmospheric chemistry processes that result in the formation of tropospheric ozone. They are important inputs to atmospheric chemistry models and can have a significant effect on the selection of emission control strategies.

7.3.2 Sector Description

This sector includes VOC and NO emissions from plants and soils. These biogenic emissions are precursors to the formation of tropospheric ozone.

Various environmental factors as well as emission rates must be considered when estimating biogenic emissions. Land cover and land use information as well as hourly meteorological data such as surface temperature and cloud opacity for the study area are important variables influencing these natural emissions. Emission rates or emission factors must account for the considerable variation exerted by vegetation type and soil use.

7.3.3 Inventory Method

Various environmental components as well as standard emission factors are used to estimate emissions from natural sources. For the 2000 inventory year, biogenic emissions for all of Canada were estimated using GloBEIS Version 3.1 (Yarwood et al. 2003). This model was developed by the U.S. National Center for Atmospheric Research. It estimates biogenic emissions of VOCs and soil NO for any scale and domain. Domains can be represented by numerous types of geographic units, such as grid systems or administrative areas. The model runs in Microsoft ACCESS on Windows-based personal computers. Emission rates are a function of land covers/uses and environmental conditions, which are characterized from user-supplied data applying the most updated emission algorithms (Guenther et al. 1999).

Input data files containing information aggregated by grid cell for the whole domain are required to run the model. These include:

- domain (or study area) definition;
- land cover and land use distribution;
- hourly surface temperature values;

- hourly cloud opacity values; and
- other optional hourly input data, such as photosynthetically active radiation, LAI, humidity, wind speed, drought index and antecedent temperature values.

These inputs can be integrated into the model through input files or by manual entry. Manual input allows for distinct values for different days for each cell rather than applying a single value to represent each vegetation type.

Other internal input information for land cover/use types observed in the domain area is also taken into consideration when running the model. Model information can include:

- standard emission factors ($\mu g/m^2$ per hour) by VOC species (isoprenes, total monoterpenes, other VOCs);
- default LAI values;
- default canopy types; and
- default LMD values (g/m^2).

Table 7.3-1 provides emission factors, LAI, canopy types and LMD values by land cover/use type that is available and pertinent for the estimation of biogenic emissions in Canada.

Table 7.3-1: Biogenic VOC and NO Emission Factors and Related Canopy Information

Land cover / use	Description	Canopy type	Emission factors ($\mu g/m^2$ per hour)				LAI	LMD (g/m^2)
			Isoprenes	Total mono-terpenes	Other VOCs	NO		
99001	Fir	3	170	5100	2775	4.5	7	1500
99002	Maple	1	42.5	680	693.7	4.5	5	350
99003	Alfalfa	7	19	7.6	11.4	12.8	4	3250
99004	Barley	7	7.6	19	11.4	256.7	4	1290
99005	Barren Lands	4	0	0	0	0	0.001	0.1
99006	Birch	1	42.5	85	693.7	4.5	5	375
99007	Coniferous Forest	3	745.4	1366.6	993.9	4.5	9	537
99008	Corn	7	0.5	0	0	577.6	4	1610
99009	Grass	6	1050	660	770	57.8	2	416
99010	Hay	7	56.2	140.5	84.3	12.8	4	150
99011	Eastern Red Cedar	3	37.8	94.5	56.7	4.5	4	540
99012	Larch	1	79.3	476	1295	4.5	7	700
99013	Poplar	1	42.5	42.5	693.7	4.5	5	375
99014	Miscellaneous Crops	7	42.5	85	693.7	12.8	5	375
99015	Oats	7	7.6	19	11.4	256.7	4	740
99016	BEIS Other Deciduous Forest	1	7.6	19	11.4	4.5	4	750
99017	Other	4	2112.4	368.8	871.8	57.8	6	471
99018	Pasture	6	56.2	140.5	84.3	57.8	4	150
99019	Peanuts	7	0	0	0	12.8	0.0001	0.1
99020	Spruce	3	56.2	140.5	84.3	4.5	4	46
99021	Pine	3	102	255	153	4.5	4	740
99022	Potatoes	7	23 800	5100	2775	192.5	7	1500
99023	Douglas Fir	3	79.3	2380	1295	4.5	3	700
99024	Rangeland	6	9.6	24	14.4	57.8	4	1720
99025	Rye	7	170	2720	2775	12.8	7	1500
99026	Scrub	5	37.8	94.5	56.7	57.8	4	375
99027	Snow and Ice	4	7.6	19	11.4	0	4	2430
99028	Sorghum	7	37.8	94.5	56.7	577.6	4	31
99029	Soybeans	7	11 450	1134	1140	12.8	5	616
99030	Tobacco	7	0	0	0	256.7	4	0.1
99031	Eastern Hemlock	1	7.8	19.5	11.7	4.5	4	3180
99032	Tundra	4	22	0	0	57.8	4	740
99033	BEIS Urban (.2 grass/.2 forest)[1]	4	0	58.8	235.2	12.5	4	490
99034	Water	4	79.3	158.7	1295	0	7	700
99035	Wheat	7	2411.7	120.6	150.7	192.5	4	82
99036	Wetlands	4	408.6	161.9	200.5	0.2	4	108
99037	Mixed Forests	2	0	0	0	4.5	0.001	0.1
99999	Outside Area	1	15	6	9	0	4	740

1. The BEIS Urban category is represented by 20% grass, 20% forest and 60% other non-vegetation cover.

7.3.4   Activity Level

The activity-level information that is used as input data to estimate and geographically disseminate biogenic VOC and NO emissions includes various input data, including:

- land cover and land use information (Table 7.3-2) from the 1992 Canada Land Cover map. This map was generated using U.S. National Oceanic and Atmospheric Administration Advanced Very High Resolution Radiometer images. The pixel resolution is about 1 km;
- hourly surface temperature and cloud opacity for all weather stations across Canada for the year 2000 (Environment Canada 2000); and
- agricultural crop data information from the Statistics Canada (2001) Census of Agriculture (Table 7.3-3).

Table 7.3-2: Land covers and uses

Class	Description
1	Mixed Forest
2	Deciduous Forest
3	Water
4	Transitional Forest
5	Coniferous Forest
6	Tundra
7	Barren Land
8	Ice or Snow
9	Agricultural Cropland
10	Agricultural Rangeland
11	Built-up Area
12	Sea Ice Polar Cap

Table 7.3-3: Crop type

Crop types	
Alfalfa and alfalfa mixtures	Mustard seed
All other tame hay and fodder crops	Oats
Barley	Other dry beans
Buckwheat	Other field crops
Canary seed	Potatoes
Canola (rapeseed)	Safflower
Caraway seed	Soybeans
Chick peas	Spring rye
Corn for grain	Spring wheat (excluding durum)
Corn for silage	Sugar beets
Dry field peas	Sunflowers
Dry white beans	Tobacco
Durum wheat	Total dry field beans
Fall rye	Total rye
Flaxseed	Total wheat
Forage seed for seed	Triticale
Ginseng	Variables
Lentils	Winter wheat
Mixed grains	

7.3.5 Comparison of 2000 Methods with Previous Methodology

For the 1990 and 1995 inventory years, CANBEIS1 and CANBEIS2 were used to estimate non-methane biogenic VOC and NO emissions. Those models were Canadianized versions of the latest available models developed by the U.S. Environmental Protection Agency (e.g., PC-BEIS and PC-BEIS2). The Canadian models use geographic information systems and related information. CANBEIS1 and CANBEIS2 estimates are comparable and consistent with the American model estimates.

7.3.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methods used by the provinces/territories.

7.3.7 References

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7.3.8   Guidebook Sector Documentation Record

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OPEN SOURCE SECTOR

7.4   CONSTRUCTION OPERATIONS

7.4.1   General Description

Across all types of construction operations (except residential construction), central Canada (Ontario and Quebec) represent 50% of the expenses, Alberta 20%, British Columbia 12% and 18% is distributed among the remaining provinces and territories.

7.4.2   Sector Description

The construction operation sector addresses particulate emissions that result from heavy machinery operations, including excavation, levelling, loading, unloading and compaction, and all vehicular movement. Residential, commercial, institutional and engineering construction operations produce the majority of the fugitive particulate matter.

Emissions from construction equipment fuel combustion by off-road vehicles and engines are inventoried as part of off-road use of diesel and gasoline and also in the Industrial Fuel Combustion section.

7.4.3   Inventory Method

The emission estimation methods for Residential Construction, Industrial, Commercial, Institutional (ICI) construction and Engineer construction are still based on the area of construction. However, new emission factors more specific to the activity were used as well as more appropriate parameters for climatic and soil conditions were used for their estimation in the 2002 inventory. They are described below, per source:

Residential Construction:

The U.S. EPA method for estimating fugitive dust emissions from residential construction is based on the area used and the amounts of dirt displaced, in the case of Single-family home that have a basement.
The emission factors for residential construction are presented below:

Table 7.4-1: U.S. EPA method for residential construction - Emission factors and duration

Dwelling type	Emission factor	Duration
Single-family, with basement	0.011 tons PM10/acre-month + 0.059 tons PM10/1,000 cubic yards dirt moved (0.025 tonnes PM10/ha-month + 0.070 tonnes PM10/1,000 m³ of dirt moved)	6 months
Single-family, without basement	0.032 tons PM10/acre-month (0.072 tonnes PM10/ha-month)	6 months
Two-family	0.032 tons PM10/acre-month (0.072 tonnes PM10/ha-month)	6 months
Apartments	0.11 tons PM10/acre-month (0.25 tonnes PM10/ha-month)	12 months

Ref: CAC Fugitive Emissions from the Canadian Construction Sector, Lavalin, August 2005.

Institutional, Commercial and Industrial Construction (ICI):
The emission factor used for ICI and Engineering is 0.19 tons PM10/acre-month (0.426 tonnes PM10/ha-month)

Table 7.4-2 : Institutional, Commercial, Industrial construction–unadjusted emission factors and duration

Sector	Unadjusted emission factor (tonnes PM10/ha-month)	Duration (months)
Industrial Building Construction		
1) Plants-Manufacturing, Processing and Assembling Goods	0.426	11
2) Other Industrial Building Construction	0.426	11
Commercial Building Construction		
1) Office Buildings	0.426	11
2) Shopping Centers, Malls, Stores	0.426	11
3) Indoor Recreational Buildings	0.426	11
4) Other Commercial Building Construction	0.426	11
Institutional Building Construction		
1) Schools, Colleges, Universities	0.426	11
2) Hospitals, Health Centres, Clinics	0.426	11
3) Nursing Homes, Homes for the Aged	0.426	11
4) Penitentiaries, Detention Centres	0.426	11
5) Other Institutional and Governmental Construction	0.426	11
Other Non-Residential Building Construction		
1) Other Non-Residential Building Construction	0.426	11

Ref: CAC Fugitive Emissions from the Canadian Construction Sector, Lavalin, August 2005.

Engineering Construction:
The following emission factors were used; they are specific to each construction category, instead of only one emission factor (0.19 tons PM10/acre-month or 0.43/ha-month) used in the past.

Table 7.4-3: Emission factors for Engineering Construction

Construction sub type	Emission factor	Source
outdoor recreational facilities and bridges.	0.265 ton PM10/acre-month (0.594 tonnes/ha-month)	Clark County, US
Buildings (mine buildings) and plants	0.19 ton PM10/acre-month (0.43 tonnes/ha-month)	Used by EPA for ICI construction.
All other heavy construction types.	0.42 ton PM10/acre-month (0.94 tonnes/ha-month)	Used by EPA for roadway construction

Ref: CAC Fugitive Emissions from the Canadian Construction Sector, Lavalin, August 2005.

7.4.4   Activity Level

The activity level for this sector is the area of construction. For Residential construction the area of construction is derived from the number of housing starts, however for the ICI and the Engineering construction it is based on the area of construction derived from the construction expenditures by type of asset.

Construction expenditures by type of asset and by province and territory were obtained from Statistics Canada Catalogue No. 61-223-XIB Table 29-0040 . A conversion factor was required to convert construction expenditures to construction area, for Institutional, Commercial and Industrial construction as well as for Engineering construction.

The number of housing starts was derived from the Canadian Mortgage and Housing Corporation (CMHC) in table 14, entitled "Dwelling Starts by Type, by Region and Province, 1993-2003". These numbers were not available for Yukon, Northwest Territories and Nunavut and construction expenditures were used for the estimation of construction area.

The number of months of construction varies with the type of construction. However, since particulate emissions generally occur at the beginning of the project and are negligible at other times (i.e., interior construction, rainy days, etc.), correction factors were applied to the total number of months of construction. The correction factors applied were a climate correction factor (used to eliminate particulate emissions on rainy days), a relevant construction activity correction factor Fs (used to eliminate construction activities that do not produce particulate emissions), and a number of construction months correction factor, Fm (used to eliminate months when particulate emissions are negligible).

Table 7.4-4: Engineering construction - Fs and Fm correction factors

Construction Sector	Fs	Fm
Marine Engineering Construction	0.80	1.00
Transportation Engineering Construction	0.90	1.00
Waterworks Engineering Construction	0.80	1.00
Sewage Engineering Construction	0.75	0.50
Electric Power Engineering Construction	0.75	1.00
Communication Engineering Construction	0.75	1.00
Oil and Gas Engineering Construction	0.80	1.00
Mining Engineering Construction	0.90	1.00
Other Engineering Construction	0.80	1.00

Ref: CAC Fugitive Emissions from the Canadian Construction Sector, Lavalin, August 2005.

7.4.5   Comparison of 2002 Methods with Previous Methodology

Table 7.4-5: Changes from the previous method with Residential, ICI and Engineering construction types

Type	Changes from previous method
Residential Construction	• New method uses surface area estimated from building-to-area conversion factor and the number of housing starts to estimate the area of land affected by construction. • More up to date durations for construction work. • Soil moisture, silt content and mitigation efficiency accounted for. • Fs, Fm, Fc removed. • Exceptions: Yukon, Nunavut and Northwest Territories, where the new method is used, but where capital expenditure data and dollars-to area conversion factors derived from Canadata are used to estimate the area of land affected by construction.
Industrial, Commercial, Institutional (ICI) Construction	• Still using dollars-to-area conversion factors; however conversion factors are derived from Canadata. • More up to date durations for construction work. • Use of more recent EPA emission factors. • Soil moisture, silt content and mitigation efficiency accounted for. • Fs, Fm, Fc removed and replaced by silt content and soil moisture.
Engineering Construction	• More recent and intensity-related emission factors are used. • Fc removed and replaced by silt content and soil moisture. • Mitigation efficiency accounted for. • For roads, dollars-to-km and km-to-area conversion factors from EPA (but validated for Canada) are used.

Ref: CAC Fugitive Emissions from the Canadian Construction Sector, Lavalin, August 2005.

7.4.6   Alternative Methods Used by Provinces/Territories

Methods used to estimate emissions in the Lower Fraser Valley were used to estimate emissions for all of British Columbia for this sector (GVRD and FVRD 2003). The next paragraph is extracted from GVRD and FVRD (2003).

The methodology for estimating particulate emissions from construction and demolition was based on an emission factor expressed in t/\$1000 of construction activity. This emission factor was reviewed and adjusted to a 2000 basis (using consumer price indices). The resulting emission factor for 2000 was 0.064 kg PM/\$1000 construction activity. The total particulate factor was then prorated as 21% PM_{10} and 4% $PM_{2.5}$ (or 0.013 and 0.0026 kg/\$1000), using standard speciation profiles from the U.S. EPA for construction and demolition. Base quantities were obtained by using the dollar value of building permits issued in the Canadian portion of the Lower Fraser Valley study area in 2000. These were supplied by the Data Services Section of B.C. Statistics (2002), complete with municipal breakdowns. The overall total was \$2682 million in construction activity (GVRD and FVRD 2003).

7.4.7 References

B.C. Statistics. 2002. Data provided by Data Services Section.

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CHS-Residential Building Activity, "Dwelling Starts, Completions, Under Construction and Newly Completed and Unabsorbed Dwellings - 2005", April 2006

7.4.8 Guidebook Sector Documentation Record

Release Version: 1

Date: October 2005

Author: Pollution Data Division

OPEN SOURCE SECTOR

7.5   DUST FROM PAVED ROADS

7.5.1   General Description

See below.

7.5.2   Sector Description

This sector covers particulate emissions that result from vehicles travelling on paved roads. Particulate emissions due to tire and brake lining wear are considered in a separate section (section 4.1) under the transportation sector.

When vehicles travel on paved roads, the silt, dust and other particles that are present on the road surface are disturbed by mechanical actions and turbulence generated by the vehicle passage and can become airborne, thus leading to particulate emissions to the air.

7.5.3   Inventory Method

This sector was inventoried as an area source. An empirical equation, taken from AP-42, Section 13.2.1 (U.S. EPA 1995), and given below, was used to generate estimates of particulate emission factors, E (kg/VKT):

$$E = k \left(\frac{s_L}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5} \frac{365 - snow}{365}$$

where k is the base emission factor for the particle size range (g/VKT), s_L is the road silt loading (g/m^2), W is the average weight (t) of the vehicles travelling the road and *snow* is the number of days per year on which snow covers the road.

Particle size multipliers (k) for paved roads (U.S. EPA 1995) are 24 g/VKT for TPM, 4.6 g/VKT for PM$_{10}$ and 1.1 g/VKT for PM$_{2.5}$.

In using the equation, it was assumed that no particulate emissions occur on days when the road surface is covered with either fresh or packed snow.

7.5.4   Activity Level

In order to use the AP-42 equation to obtain an emission estimate, information regarding the average vehicle weight, road type, silt loadings and distance travelled on the road is required. The number of days with precipitation and the number of days on which the road is covered in snow are also required.

For each province and territory, the vehicle fleet was divided into eight classes: heavy-duty diesel trucks, heavy-duty gasoline trucks, light-duty diesel trucks, light-duty diesel vehicles, light-duty gasoline trucks, light-duty gasoline vehicles, motorcycles and taxis. Weight, number of tires and average speed were assigned for each vehicle class. Total kilometres travelled for each vehicle class in 2000 by province and territory were generated from vehicle use statistics from DesRosiers Automotive Consultants (2002) and R.L. Polk & Co.

The road networks in 2000 were assumed to be the same as those used for the 1995 inventory. Information on roads in 1995 in Canada was taken from a Natural Resources Canada Road Network Information database (GeoCom Inc. 1997). Road classes were divided into five categories: highway, primary road, secondary road, street (residential) and limited-access road. Silt loadings by road type were extracted from road dust reports (AGRA Earth & Environmental Ltd. 1997; Golder Associates 1997; Innovacorp 1997; John D. Paterson & Associates Ltd. 1997; NEIPTG 1997) and extrapolated to missing road types and provinces/territories not covered in the reports. Vehicle class mixes and the percentage of total kilometres driven were assumed for each of the five road classes, as detailed in the road transportation methods in chapter 4.

Precipitation (both rain and snow) data in 2000 in Canada were available through an Atmospheric Environment Service database (Environment Canada 2000). During Canadian winters, the roads in most areas are not completely cleared of snow, except for those falling under the highway category. The current inventory method assumes that during snowfall events, no particulate emissions occur. In addition, for the remaining road categories, no particulate emissions occur during the period in which the roads are covered with snow. To account for snow-covered roads, it was necessary to assume dates on which snow first covered the road and on which the packed snow was completely melted. These dates were assumed valid for the entire province or territory, except for British Columbia, which had regional data available.

Due to the variability of precipitation across a province or territory and the increasing need for emission information to be calculated at a regional or city level, a geographical information system was utilized in estimating the emissions. Using the geographical information system, the data within the road and precipitation databases were interpolated for small grids (i.e., 10–25 km). Total vehicle kilometres by vehicle type could then be prorated for each grid, based on the ratio of the vehicle class mixes and the proportion of total kilometres of each road type within a grid cell, and multiplied by the appropriate emission factor to obtain an emission estimate.

7.5.5   Comparison of 2000 Methods with Previous Methodology

There were no changes in methodology from the 1995 inventory for this sector.

7.5.6 Alternative Methods Used by Provinces/Territories

For British Columbia outside of the Lower Fraser Valley, the methodology is the same as that used for the other provinces. Methods used to estimate emissions in the Lower Fraser Valley are included in the report *2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed* (GVRD and FVRD 2003). In this report, there is no distinction between paved roads and unpaved roads.

7.5.7 References

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7.5.8   Guidebook Sector Documentation Record

Release Version: 1

Date: July 2004

Author: Pollution Data Division / Canadian ORTECH Environmental

OPEN SOURCE SECTOR

7.6   DUST FROM UNPAVED ROADS

7.6.1   General Description

See below.

7.6.2   Sector Description

This sector covers particulate emissions that result from vehicles travelling on unpaved roads. Particulate emissions due to tire and brake lining wear are considered in a separate section (section 4.1) under the transportation sector.

When vehicles travel on unpaved roads, the silt and dust that are present on the road surface are disturbed by mechanical action and turbulence generated by the vehicle passage over the road surface. This results in particulate emissions to the air.

7.6.3   Inventory Method

This sector was inventoried as an area source. An empirical equation, taken from AP-42, 5th edition, Section 13.2.2 (U.S. EPA 1995), and given below, was used to generate estimates of particulate emission factors, *E* (kg/VKT):

$$E = 1.7\, k \left(\frac{s}{12}\right)\left(\frac{S}{48}\right)\left(\frac{W}{2.7}\right)^{0.7}\left(\frac{w}{4}\right)^{0.5}\frac{365 - \left(p + snow\right)}{365}$$

where *k* is the base emission factor for the particle size range (dimensionless), *s* is the silt content of the road material (%), *S* is the mean vehicle speed (km/h), *W* is the average weight of the vehicles travelling the road (t), *w* is the mean number of wheels, *p* is the number of days per year with at least 0.254 mm of precipitation and *snow* is the number of days per year on which snow covers the road. Base emission factors (*k*) for unpaved roads (U.S. EPA 1985) are 1.00 for TPM, 0.36 for PM_{10} and 0.095 for $PM_{2.5}$.

In using the equation, it was assumed that no particulate emissions occurred on days with rainfall exceeding 0.254 mm and on days when the road surface is covered with either fresh or packed snow.

7.6.4   Activity Level

In order to use the AP-42 equation to obtain an emission estimate, information regarding the average vehicle weight, speed and number of wheels as well as road type, silt content of road surface material and distance travelled on the road is required. The number of days with precipitation and the number of days on which the road is covered in snow are also required.

For each province and territory, the vehicle fleet was divided into eight classes: heavy-duty diesel trucks, heavy-duty gasoline trucks, light-duty diesel trucks, light-duty diesel vehicles, light-duty gasoline trucks, light-duty gasoline vehicles, motorcycles and taxis. Weight, number of tires and average speed were assigned for each vehicle class. Total kilometres travelled for each vehicle class in 2000 by province and territory were obtained from the DesRosiers Automotive Consultants (2002) and R.L. Polk & Co. databases.

The road networks in 2000 were assumed to be the same as those used for the 1995 inventory. Information on roads in 1995 in Canada was taken from a Natural Resources Canada Road Network Information database (GeoCom Inc. 1997). Road classes were divided into five categories: highway, primary road, secondary road, street (residential) and limited-access road. Silt content of surface material by road type was extracted from road dust reports (AGRA Earth & Environmental Ltd. 1997; Golder Associates 1997; Innovacorp 1997; John D. Paterson & Associates Ltd. 1997; NEIPTG 1997) and extrapolated to missing road types and provinces/territories not covered in the reports. Vehicle class mixes and the percentage of total kilometres driven were assumed for each of the five road classes, as detailed in the road transportation methods in chapter 4.

Precipitation (both rain and snow) data in 2000 in Canada were available through the Environment Canada Atmospheric Environment Service database (Environment Canada 2000). During Canadian winters, the roads in most areas are not completely cleared of snow, except for those falling under the highway category. The current inventory method assumes that during snowfall events, no particulate emissions occur. In addition, for the remaining road categories, no particulate emissions occur during the period in which the roads are covered with snow. To account for snow-covered roads, it was necessary to assume dates on which snow first covered the road and on which the packed snow was completed melted. These dates were assumed valid for the entire province or territory, except for British Columbia, which had regional data available.

Due to the variability of precipitation across a province or territory and the increasing need for emission information to be calculated at a regional or city level, a geographical information system was utilized in estimating the emissions. Using the geographical information system, the data within the road and precipitation databases were interpolated for small grids (i.e., 10–25 km). Total vehicle kilometres by vehicle type could then be prorated for each grid, based on the ratio of the vehicle class mixes and the proportion of total kilometres of each road type within a grid cell, and multiplied by the appropriate emission factor to obtain an emission estimate.

7.6.5   Comparison of 2000 Methods with Previous Methodology

There were no changes in methodology from the 1995 inventory for this sector.

7.6.6 Alternative Methods Used by Provinces/Territories

For British Columbia outside of the Lower Fraser Valley, the methodology is the same as that used for other provinces. Methods used to estimate emissions in the Lower Fraser Valley are included in the report *2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed* (GVRD and FVRD 2003). In this report, there is no distinction between paved roads and unpaved roads.

7.6.7 References

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7.6.8   Guidebook Sector Documentation Record

Release Version: 1

Date: July 2004

Author: Pollution Data Division / Canadian ORTECH Environmental

OPEN SOURCE SECTOR

7.7   FOREST FIRES

7.7.1   General Description

In 2000, Canada as a whole experienced a below-average year for the number of fires and for total hectares burned. In total, 5438 fires were recorded in 2000, for a total of 647 071 ha burned, compared with the 10-year average of 8486 fires, for a total of 2 789 716 ha burned. While the most fires occurred in British Columbia, the largest number of hectares consumed was in the Northwest Territories, closely followed by Newfoundland and Labrador and Saskatchewan (Johnston undated).

7.7.2   Sector Description

This sector covers the emissions of criteria air pollutants from the combustion of forest material. Forest fires (also called wildfires) release large quantities of particulate matter, CO and VOCs, moderate quantities of NO_x and small amounts of SO_x and NH_3.

The size and intensity of a forest fire depend directly on such variables as meteorological conditions, the type of vegetation involved (and moisture content) and the weight of consumable fuel per hectare (U.S. EPA 1995).

The temperature gradient, oxygen supply and burning time affect the degree of combustion in a forest fire. The size and quantity of the forest fuels, meteorological conditions and topographic features combine to change the burning patterns as the fire spreads, and so different levels of combustion efficiency occur during the course of a forest fire. Accurate fuel loading estimates are considered to be essential in estimating emissions from forest fires (U.S. EPA 1985).

7.7.3   Inventory Method

This sector was inventoried as an area source using appropriate emission factors and activity levels. With the exception of SO_x, emission factors for forest fires, used for all provinces except British Columbia, were derived from AP-42, Sections 1.6 and 13.1 (U.S. EPA 1985), and are given in Table 7.7-1. The emission factor for SO_x was taken from a Canadian Forest Service report (Taylor and Sherman 1996).

Table 7.7-1: Emission Factors for Forest Fires

Province	Emission factors (kg/t of burned material)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3
All provinces	8.500	7.225	5.950	0.005	2.230	9.600	70.000	0.150
Lower Fraser Valley	17.0	13.0	12.0	0.005	1.5	4.27	101.0	0.32
British Columbia	19.610	15.000	13.500	0.05	2.0	4.271	102	1.2

7.7.4   Activity Level

The activity level for this sector is the mass of material that was consumed in forest fires in 2006. 2006 AL data was obtained from the CIFFC Canada report 2006. In order to convert the area consumed by fire to a mass consumed by fire, two conversion factors were utilized: 22.4 t/ha for timber productive forests and 12.2 t/ha for non-productive forests, as provided by the Forest Fire Division of Natural Resources Canada. Since only the total area is available the average of t/ha was taken.

7.7.5   Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology, activity levels are no longer taken from the National Forestry Database (Canadian Council of Forest Ministers).

7.7.6   Alternative Methods Used by Provinces/Territories

Alternative methods were used to estimate emissions in the Lower Fraser Valley in British Columbia for this sector. Documentation of the methods is included in the report *2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed* (GVRD and FVRD 2003).

For the rest of British Columbia, forest fire statistics from the Canadian Forest Service and B.C. Ministry of Forests were combined with emission factors from AP-42 (U.S. EPA 1995), EC/R Inc. (2002) and E.H. Pechan & Associates (undated) to estimate emissions.

7.7.7   References

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7.7.8   Guidebook Sector Documentation Record

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Author: Pollution Data Division / Canadian ORTECH Environmental

OPEN SOURCE SECTOR

7.8   LANDFILL SITES

7.8.1   General Description

Ontario and Quebec represent more than sixty percent of the waste material deposited in landfills in Canada, with Alberta and British Columbia contributing another 24% of the material landfilled in year 2003.

7.8.2   Sector Description

The emissions from landfills are mainly CH_4 and associated VOCs found in small concentrations in the landfill gas escaping the sites. In addition, particulate emissions occur due to wind erosion and the movement of heavy vehicles.

Landfill disposal sites are used for a variety of solid and liquid wastes, such as:

- domestic waste;
- commercial waste;
- hazardous waste;
- liquid waste;
- non-hazardous solid industrial waste; and
- sewage sludge.

Disposal sites may be designated to receive only one or a selection of the above waste materials. The materials deposited in the landfill are progressively covered with soil to prevent scattering of litter by wind, to prevent scavenging by rodents and other animals and to contain odours. The organic materials in the waste decay over a period of decades, with the evolution of mainly CO_2 and CH_4 in roughly equal proportions by volume. The decay process, which is mainly anaerobic, is dependent on the type of waste and its moisture content, as well as many other factors that influence the bacterial activity.

The landfill gases move out of the landfill carrying other volatiles. In uncontrolled landfills, the gas permeates through the surface soil to the atmosphere. Placing gas collection pipes in the dump and burning the gas and associated VOCs in a flare can help control landfill emissions. Capping the landfill with clay or other low-permeability cover can enhance gas collection. Once the landfill site has been filled to capacity, the site is closed with a layer of soil and a vegetative cover. Significant gas evolution from the site will continue for 20–30 years. Those sites equipped with gas collection equipment maintain flares or useful combustion equipment for as long as there is sufficient gas to burn. Gas evolution is not entirely steady, but varies with infiltration of moisture. Changes in barometric pressure will also modulate the gas flow as pressure changes in the void space of the landfill.

7.8.3   Inventory Method

This sector was inventoried as an area source using appropriate emission factors and activity levels. Emission factors for VOCs are calculated as the ratio of VOC emissions, derived from CH_4 emissions, to the amount of waste landfilled. CH4 emissions are estimated using the Scholl Canyon Model, and the conversion of CH4 to VOC is done using the following equation from the USEPA:

$$Q_{VOC} = 1.82 \; Q_{CH_4} \cdot [C_{VOC} / (1 \times 10^6)]$$

Ref: AP-42, Section 2.4 (U.S. EPA 1995)

where:

Q_{VOC}	=	emission rate of VOC (m^3/year)
Q_{CH_4}	=	CH_4 generation rate (m^3/year) (from Scholl Canyon model)
C_{VOC}	=	concentration of VOC in landfill gas (ppmv); and
1.82	=	multiplication factor (assumes that approximately 55% is CO_2, N_2 and other constituents).

Two estimates of the VOC concentration were used. A concentration of 2060 ppmv VOC was used to represent waste containing 100% hazardous waste, and a concentration of 235 ppmv was used for waste containing no hazardous waste. For the purposes of this estimate, it was assumed that 50% of each type of disposal was practised in all provinces/territories. A factor of 0.003 585 t/m^3 was use to convert the VOC volume to mass. Finally, an average emission factor for each province/territory was derived by dividing the VOC 2002 emissions by the mass of waste landfilled.

Table 7.8-1 summarizes these emission factors used for 2003. Emission factors for Nunavut were assumed to be the same as those for the Northwest Territories.

Table 7.8-1: VOC Emission Factors for Landfill

Province/territory	VOC Emission factors (kg/Tonne)
Newfoundland	0.415850
Prince Edward Island	0.353380
Nova Scotia	0.457846
New Brunswick	0.328794
Quebec	0.538578
Ontario	0.432293
Manitoba	0.283400
Saskatchewan	0.178512
Alberta	0.158676

British Columnia[1]	
Northwest Territories	0.081800
Yukon	0.076927
Nunavut	0.084543

Ref: Langdem Software, Greenhouse Gas Division (Communication with Craig Palmer).
Note:
1. See section 7.8.6, Alternative Methods Used by Provinces/Territories.

Particulate emission factors were derived using information contained in the 1995 British Columbia inventory (Gibson 1998) and were assumed to be applicable to the rest of Canada. Table 7.8-2 summarizes the emission factors for particulate.

Table 7.8-2: Particulate Emission Factors for Landfill

Source	Emission factors (kg/t of waste landfilled)		
	TPM	PM_{10}	$PM_{2.5}$
Landfill	0.1930	0.0154	0.0039

Ref: B.C. Ministry of Environment, Land and Parks, 1997

7.8.4 Activity Level

The activity level for this sector is the quantity of waste landfilled for each province and territory.

For the 2002 inventory, the provincial amounts of waste sent to landfill was derived based on the per capita landfill rate for 1995 and the population for 2002. The activity levels for the Northwest Territories were distributed between the Northwest Territories and Nunavut based on the populations of these territories.

Table 7.8-3: Amount of waste landfilled for 2003.

Province/territory	Amount of waste landfilled(Megatonnes)
Newfoundland	0.337721
Prince Edward Island	0.078811
Nova Scotia	0.761924
New Brunswick	0.571952
Quebec	5.705223
Ontario	7.612223
Manitoba	1.172078
Saskatchewan	0.768019
Alberta	2.64282
British Columbia[1]	
Northwest Territories	0.033456
Yukon	0.02130716
Nunavut	0.02347782

Province/territory	Amount of waste landfilled(Megatonnes)

Ref: Langdem Software, Greenhouse Gas Division (Communication with Craig Palmer).

1 British Comlumbia has their own method. (see table 7.8-3)

7.8.5   Comparison of 2006 Methods with Previous Methodology

In 1995, emissions of VOCs were based on that year's landfill amount, while the 2003, 2002 and 2000 estimates are based on a model that takes into account the fact that emissions arise from waste deposited over several years. Emission factors are backcasted from the model output, using the amount of waste landfilled, and they are specific to each province.

7.8.6   Alternative Methods Used by Provinces/Territories

Methods used to estimate emissions in the Lower Fraser Valley are included in the report *2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed* (GVRD and FVRD 2003). For British Columbia outside of the Lower Fraser Valley, emission factors (Table 7.8-3) are from Gibson (1998).

Table 7.8-3: Emission Factors for Landfills for British Columbia Outside of the Lower Fraser Valley

Landfills	Emission factors (kg/t of waste landfilled)			
	TPM	PM$_{10}$	PM$_{2.5}$	VOCs
Municipal and industrial	0.1930	0.0695	0.0193	0.777
Wood residue landfills	0.1930	0.0695	0.0193	2.216

Ref: Gibson (1998).

References

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7.8.8   Guidebook Sector Documentation Record

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Author: Patrick Georges, Pollution Data Division

OPEN SOURCE SECTOR

7.9   MINE TAILINGS 2006

7.9.1   General Description

Central Canada (Ontario and Quebec) produces the majority of the national total of mine tailings, while Saskatchewan and British Columbia generate a smaller proportion.

7.9.2   Sector Description

This sector covers particulate emissions resulting from wind erosion from mine tailings deposits at non-operating and operating mine sites.

Concentrating minerals from their respective ores results in a solid waste that leaves the mill as a slurry. The slurry is channelled to a tailings pond, where the solids settle out of suspension. When the pond is filled or is no longer in use, the water usually drains away in time or is evaporated. The dry tailings matter is then susceptible to wind erosion.

7.9.3   Inventory Method

This sector was inventoried as an area source using appropriate emission factors and activity levels. Emission factors were derived using Evans and Cooper (1980) and are dependent on climate factors, such as wind speed, precipitation and temperature. Two emission factors for TPM were calculated: 1.789 t/ha for the eastern provinces and 7.7517 t/ha for the western provinces. These emission factors are identical to the ones developed for the 1980 and 1985 inventories (Environment Canada 1986, 1990). Emission factors for PM_{10} and $PM_{2.5}$ were obtained by multiplying the emission factor for TPM by 0.08 and 0.02, respectively, as given by the U.S. EPA's PM Calculator tool. Emission factors are given in Table 7.10-1.

Table 7.10-1: Particulate Emission Factors for Mine Tailings

Source	Emission factors (t/ha)		
	TPM	PM_{10}	$PM_{2.5}$
Mine tailings, eastern provinces	1.789	0.1431	0.0358
Mine tailings, western provinces	7.7517	0.6201	0.1550

7.9.4 Activity Level

The activity level for this sector is the surface area of tailings piles. This information was available from Natural Resources Canada (1983), but only for the 1980 calendar year. To obtain year 2005 areas, Infometrica growth factors were used. A control efficiency of 50% is also employed to the activity level. The 2005 data was used in 2006 due to lack in activity levels.

7.9.5 Comparison of 2006 Methods with Previous Methodology

There has been no change in methodology

7.9.6 Alternative Methods Used by Provinces/Territories

There were no alternative area source methodologies used by the provinces for this sector.

7.9.7 References

Environment Canada. 1986. Emissions and Trends of Common Air Contaminants in Canada: 1970 to 1980. Report EPS 7/AP/17. Environmental Protection Service, Environment Canada. September.

Environment Canada. 1990. Canadian Emissions Inventory of Common Air Contaminants (1985). Report EPS 5/AP/3. Environmental Protection Service, Environment Canada. March.

Evans, J.S. and Cooper, D.W. 1980. An Inventory of Particulate Emissions from Open Sources. Journal of the Air Pollution Control Association 30(12): 1298–1303.

Infometrica. 2002. Growth Factor Database.

Natural Resources Canada. 1983. Pit Slope Manual: Mine Waste Inventory by Satellite Imagery. Supplement 10-1, Volume 2.

7.10.8 Guidebook Sector Documentation Record

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Author: Lynn Nadon, Pollution Data Division

OPEN SOURCE SECTOR

7.10   PRESCRIBED BURNING

7.10.1 General Description

In Canada, in 2000, there were 12 239 ha of burns from prescribed burning. All of these occurred in British Columbia and Ontario (National Forestry Database, Canadian Council of Forest Ministers).

7.10.2 Sector Description

Prescribed burning is a controlled land management treatment used to reduce logging residues, manage forest production, control insects and minimize potential for destructive wildfires. The major pollutants resulting from prescribed burning are particulate matter, CO and VOCs. NO_x emissions are at lower rates, since combustion temperatures are low relative to most other combustion sources. SO_x emissions are considered to be low.

The practice of prescribed burning is done by the logging industry and forestry officials to manage Crown lands. Ignition or firing methods such as heading, backing, spot and flank fires are used to control fire behaviour patterns, which depend mainly on the type and moisture content of the fuel to be burned and weather/wind conditions. Of the combustion phases that occur (i.e., preheating, flaming, glowing and smouldering), the smouldering phase produces greater amounts of incomplete combustion products per fuel quantity consumed than the other phases. Control can be administered in this latter stage by rapidly extinguishing fires when lower layers of the fuel are moist.

7.10.3 Inventory Method

This sector was inventoried as an area source using appropriate emission factors and activity levels. Emission factors for this sector came from the 4th edition of the U.S. EPA's AP-42 (U.S. EPA 1985) and previous inventories. Emission factors for 2000 are the same as emission factors for 1995 (Table 7.10-1).

Table 7.10-1: Emission Factors for Prescribed Burning

Province/territory	Emission factors (kg/t)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3
Newfoundland and Labrador	18.10	15.60	10.92	0.037	1.80	5.05	163.80	0.15
Prince Edward Island	17.40	14.50	10.15	0.037	1.80	5.05	153.80	0.15
Nova Scotia	17.40	14.50	10.15	0.037	1.80	5.05	153.80	0.15
New Brunswick	17.40	14.50	10.15	0.037	1.80	5.05	153.80	0.15
Quebec	17.40	14.50	10.15	0.037	1.80	5.05	153.80	0.15
Ontario	17.40	14.50	10.15	0.037	1.80	5.05	153.80	0.15
Manitoba	15.30	13.60	9.52	0.037	1.80	5.05	123.80	0.15
Saskatchewan	15.30	13.60	9.52	0.037	1.80	5.05	123.80	0.15
Alberta	13.70	11.70	8.19	0.037	1.80	5.05	83.60	0.15
British Columbia[1]	–	–	–	–	–	–	–	–
Yukon	13.30	10.30	9.40	0.51	1.85	9.50	143.80	0.15
Northwest Territories	16.50	14.00	11.55	0.51	1.85	9.50	143.80	0.15
Nunavut	16.50	14.00	11.55	0.51	1.85	9.50	143.80	0.15

Note:
1. See section 7.10.6, Alternative Methods Used by Provinces/Territories.

7.10.4 Activity Level

The final activity level for this sector is the mass of fuel consumed by the fire. Statistics on the area of prescribed burning were taken from the CIFFC Canada report 2006. Using conversion factors for each province/territory, the area burned was converted to mass of wood waste burned (Environment Canada 1997). Table 7.10-2 shows the conversion factors used.

Table 7.10-2: Conversion Factors

Province/territory	Conversion factor (kg biomass/m^2)
Newfoundland and Labrador	7
Prince Edward Island	7
Nova Scotia	0
New Brunswick	0
Quebec	0
Ontario	8.1
Manitoba	0
Saskatchewan	0
Alberta	0
British Columbia	8
Yukon	0
Northwest Territories	0
Nunavut	0

7.10.5 Comparison of 2006 Methods with Previous Methodology

There were no changes in methodology from the 1995 inventory for this sector.

7.10.6 Alternative Methods Used by Provinces/Territories

Methods used to estimate emissions in the Lower Fraser Valley are described in the document *2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed* (GVRD and FVRD 2003). Table 7.10-3 shows the alternative Lower Fraser Valley emission factors.

Table 7.10-3: Alternative Lower Fraser Valley Emission Factors

Source	Emission factors (kg/t)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3
Prescribed burning	13.3	10.3	9.4	–	2	12	111.1	0.32

For the rest of the province, prescribed burning is divided into three subsectors: Zone 1, Zone 2 and Zone 3-4-5. Emission factors (Table 7.10-4) are from AP-42 (U.S. EPA 1995), EC/R Inc. (2002) and E.H. Pechan & Associates (undated).

Table 7.10-4: Emission Factors for Prescribed Burning for the Province of British Columbia

Subsectors	Emission factors (kg/t)							
	TPM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOCs	CO	NH_3
Zone 1	17.0	13.0	12.0	0.05	1.5	4.271	101	1.2
Zone 2	6.0	4.0	4.0	0.005	1.5	4.271	101	1.2
Zone 3-4-5	14.25	9.5	8.88	0.05	1.7	4.271	85	1.2

7.10.7 References

Canadian Council of Forest Ministers. Area of Site Preparation by Ownership, Treatment, and Province/Territory, 1990–2002. National Forestry Database. (http://nfdp.ccfm.org/compendium/data/2003/tables/com64e.htm)

EC/R Inc. 2002. Development of Emissions Inventory Methods for Wildland Fire. Prepared for the U.S. Environmental Protection Agency. February.

E.H. Pechan & Associates. Undated. PM_{10} Emission Factor Listing Developed for Technology Transfer and AIRS Source Classification Codes with Documentation. Prepared for the U.S. Environmental Protection Agency.

Environment Canada. 1997. Trends in Canada's Greenhouse Gas Emissions 1990–1995. Prepared by Art Jaques, Pollution Data Branch, Environment Canada. April.

GVRD and FVRD. 2003. 2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed. Detailed Listing of Results and Methodology. Greater Vancouver Regional District and Fraser Valley Regional District. November. (www.gvrd.bc.ca/publications/file.asp?ID=684)

U.S. EPA. 1985. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 4th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/oldeditions.html)

U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/index.html)

7.10.8 Guidebook Sector Documentation Record

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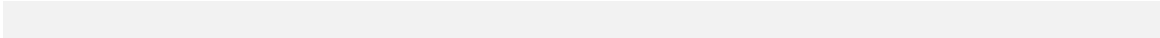
OPEN SOURCE SECTOR

7.11 OPEN BURNING 2006

7.11.1 General Description

<mark>It was estimated in 2003 that an approximate Canadian total of 126,000 tonnes and 133,000 tonnes of waste is burned in backyards and open pits, respectively. These estimations are based on the rural population of Canada, which is approximately 20% of the national population.</mark>

7.11.2 Sector Description

According to the U.S. EPA (1995) open burning is deemed to be the on-site burning of residential waste materials in open drums (barrels), baskets, or pits. A survey conducted by Environics Research Group (2001) targeted household garbage disposal and burning in rural Ontario. The survey revealed that the practice of open burning is prominent in rural areas.

Open burning can emit all criteria air contaminants, ammonia, and dioxins and furans . Many variables contribute to these emissions; such as wind, temperature of the air, moisture content of waste, and how compacted the waste is. Sulphur oxide emissions can also depend on the sulphur content of the waste being burned.

7.11.3 Inventory Method

The 2006 inventory method is based on the study conducted by Gartner Lee Limited (2003). There are major assumptions made to ensure emission methodology validity. The assumptions are:
1. On-site burning from urban areas is negligible and consequently these emissions can be considered zero
2. A rural area is any area not within urban boundaries
3. The amount of waste generated per capita is the same for rural and urban areas.
4. Depending on the province or territory, 20-40% of the rural population conducts on-site burning or waste
5. Out of the amount of waste generated per capita in rural areas, 60% is actually burned by means of open-pit or backyard burning.

The 2002 backyard and open pit waste burned, in tonnes, is found for each province and territory using the method outlined in Gartner Lee's study 2002. The 2006 tonnage is found by adding the 2002 waste burnt to the 2006 increase/decrease in population multiplied by the waist burnt in 2002 for each province. The tonnage of waste burned is then multiplied by an emission factor to obtain emissions.

2006 criteria air contaminant emission factors are taken from U.S. EPA (1995) and ammonia emission factors come from the Greater Vancouver Regional District (2003). Dioxin and furan emissions factors were taken from the Gartner Lee Limited (2003) report. Table 7.11-1 shows the emission factors used for open burning.

Table 7.11-1: Emission Factors for Open Burning

Source	TPM	PM10	PM2.5	SO_x (kg/tonne)	NO_x	VOC	CO	NH_3	D/F (ng/kg)
Backyard Burning	8	8	8	0.5	3	15	42	0.32	72.48
Open Pit Burning	8	8	8	0.5	3	15	42	0.32	72.48

7.11.1 Activity Level

With the assumptions outlined in the previous section and using various sources, the amount of waste burned for backyard and open-pit burning is estimated for each province and territory. This is done using the following formula:

Waste Generated/Capita/yr = Waste Generated (2002) + (Change in population from 2002 to 2006) * [Waste Generated (2002)]

Waste Burned (tonnes) = 2006 Population * %Rural * Waste Generated/Capita/y * %Burning * %Equipment * %Waste burned

Where:
- *2006 Population* is the population of a province/territory (Statistics Canada, 91-214-XIE, Table 2.1-1)
- *% Rural* is the percentage of the 2002 population that is considered rural for a province/territory (Statistics Canada, 91-213-XIB)
- *Waste Generation* is the amount of residential waste generated per capita in a year for a province/territory (Statistics Canada, 16F0023-XIE), (assumption #3)
- *% Burning* is the percentage of rural population in the province or territory that performs the activity of open burning (Environics, 2001), (assumption #4)
- *%Equipment* is the percent of the rural population using a particular type of burning method. These percentages are 36% for backyard burning and 38% for open-pit burning (Environics, 2001)
- *%Waste Burned* is the percent of waste that is burned when conducting open burning. This is the same for all provinces and equipment types (Gartner Lee, 2003) (assumption #5)

7.11.2 Comparison of 2006 Methods with Previous Methodology

No changes have been made to the methodology since 2003.

7.11.3 Alternative Methods Used by Provinces/Territories

No alternative methods are used by provinces/territories for 2006.

7.11.4 References

Environics Research Group. 2001. Household Garbage Disposal and Burning. Prepared for Environment Canada. March.

Gartner Lee Limited. 2003. Dioxin/Furan Emissions from On-site Residential Waste Combustion in Canada. Prepared for Canadian Council of Ministers of the Environment. February.

Greater Vancouver Regional District, BC Ministry. 2003. 2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed. November

Statistics Canada. 2002. Annual Demographics Statistics. Catalogue No. 91-213-XIB.

Statistics Canada. 2002. Waste Management Industry Survey: Business and Government Sectors. Catalogue No. 16F0023-XIE

U.S. EPA. 1995. Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. AP-42, 5th Edition (and Supplements). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (www.epa.gov/ttn/chief/ap42/index.html)

Statistics Canada. 2006. Annual Demographics Statistics. 91-214-XIE, Table 2.1-1

7.11.8 Guidebook Sector Documentation Record

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